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People as ecological participants in ecological restoration

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Abstract

Ecological restoration is becoming increasingly more important as the global population finally awakens to an important realisation – that our planet is not one of endless abundance. It is a planet of limited resources, one where over-extraction and over-pollution have detrimental and often irreversible environmental consequences. As we look for new technological ways to circumnavigate environmental problems so that the real ethical challenge (population growth) need not be addressed, ecological restoration is one of the few solutions that actually seeks to repair the planet.

Fixing atmospheric carbon, stabilising land, and increasing biodiversity are among just some of the environmental benefits of ecological restoration and as people are the catalysts of the restoration process, there are often social benefits to their involvement such as increased mental and physical wellbeing.

However, if ecological restoration is so important, why then is the science behind it (restoration ecology) so poorly defined? Some have even questioned whether restoration is even indeed a science (Halle 2007).

This thesis examines this issue and aims to investigate the place of ecology in restoration ecology. The methods used to explore this topic include (a) an examination of the current treatment of ecological theory in restoration guidance available for practitioners, and also its application in New Zealand restoration case examples; (b) a review of historical ecological theory to identify an ecological model that might represent the practice and process of development embodied in restoration, and; (c) focus group research with New Zealand restoration practitioners to test the theoretical and practical value of a conceptual ecological model (Odum 1969) as a form of theoretical guidance for restoration practitioners.

While this thesis has primarily involved researching restoration ecology in New Zealand, many of the principles, challenges and outcomes are broadly applicable to the global restoration context.

The key finding in this study was the recognition that while ecological theory provides a substantial basis for understanding restoration ecology, it does not capture one very important feature of restoration – the involvement of people. Ecological theory encompasses ecology in the absence of humans. Restoration, by its very nature, involves people interacting with ecology. Ecological theory does not recognise how people are ecological participants in the restoration, ‘assisting’ trophic trajectories in desirable directions, nor does it recognise the complexity of social factors that govern restoration objectives.

This thesis gives rise to a new scientific paradigm in researching restoration ecology – one that seeks to understand the mutually beneficial interactions that are achievable between people and ecology.

“A land ethic changes the role of Homo sapiens from conqueror of the land community to plain member and citizen of it. It implies respect for his fellow-members and also respect for the community as such.”

- Aldo Leopold, 1968

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Chapter 1

An introduction to restoration ecology – dynamics, definitions and assumptions

1.1 Introduction

Restoration ecology is a relatively young interdisciplinary science encompassing social, cultural, aesthetic, economic, political and moral values. This introductory chapter provides a broad overview of the subject in order to establish an appropriate theoretical foundation of restoration ecology suitable as the basis for subsequent chapters.

An extensive literature review supports the concepts and ideas presented in this chapter, beginning with the dynamics of restoration ecology, which include: the context (reasons and motivations driving restoration); the course of action (who and what is involved in restoration), and; the complications and challenges presently faced in restoration ecology. Specific examples from the New Zealand restoration context illustrate various points presented throughout this section.

The definitions section then follows, which expounds the historical context for the development of restoration terminologies and outlines one of the key issues impairing the establishment of a standard set of restoration definitions. A glossary of common terminologies and definitions used in this Thesis is defined.

Finally, a brief synopsis of the assumptions in restoration ecology evokes some provoking questions that establish the scope and context for the research questions in forthcoming chapters. The chapter finishes by presenting the broad aim and research objectives addressed in this Thesis.

1.2 Dynamics

1.2.1 The context – why are we doing restoration and what is driving it?

The reasons why restoration takes place are broad yet readily definable. Three key rationale for undertaking restoration are ecological, legal, and social & cultural; management may focus on any one or all of these areas, depending on the project purpose (Davis & Meurk 2001).

With an ecological focus, restorationists may set out to repair or restore degraded ecosystems or those under-represented within a protected area system. There may also be an objective to conserve the genetic variation of common native plants and animals (Atkinson 1994) or to improve ecological functioning at the landscape scale by linking protected areas and providing corridors for the dispersal of plants and animals. Ecological rationale may focus on broad objectives, such as providing habitat for native animals, buffering streams and water bodies, erosion control, or attend to a more specific need such as the reintroduction of rare or keystone species (Davis & Meurk 2001). The restoration of Tiritiri Matangi Island in New Zealand is an excellent example of a project with multiple ecological objectives. Restoration of the Island focused on habitat restoration for the primary purpose of creating an ecosystem and year round fruit supply suitable for the reintroduction of rare and endangered bird species (Drey et al. 1982).

A restoration project may also be undertaken for legal reasons. There are two major legal documents that pertain to (but do not direct) restoration in New Zealand. The first is the Convention on Biodiversity 1992, which specifies to protect and restore New Zealand's unique biodiversity and the second is New Zealand's Resource Management Act 1991, which requires New Zealanders to avoid, remedy or mitigate adverse effects on the environment [sec. 5. (2)(c) and 17]. Because effects include past impacts [sec. 3], "remedy" can be interpreted as including the restoration of previously destroyed or degraded ecosystems. As a consequence of the Act, businesses such as developers and urban planners are often required to undertake restoration as part of Resource Consent conditions, such as for mining activities.

The third rationale for undertaking restoration may take a social and cultural focus. Socio-cultural objectives could include: to create aesthetic and amenity facilities, e.g. gardens, parks and recreational areas; to provide a collection of local species of interest, e.g., arboretums; to develop a sustainable timber supply; to provide medicinal or craft plants; to provide for educational and scientific study; and to reinforce a local sense of identity (Davis & Meurk 2001). In each instance, restoration facilitates the provision of some sort of benefit or service to humans. This is not to say that a socio/cultural focus will exclude the ecological aspects of

restoration – in many cases, meeting socio/cultural objectives is dependent upon meeting ecological objectives. The case example of Tiritiri Matangi Island illustrates this well, where the objective to provide an opportunity for people to experience a native island ecosystem could not have been met if there was no native ecosystem to experience (Gailbraith 1991). In other projects, social/cultural/ecological goals are entirely integrated. For example the restoration management plan of Motuihe Island in New Zealand considers the best methods for incorporating community participation to support the implementation of management objectives focusing on the restoration of geological heritage, Maori archeological sites, European historic sites, native ecosystems (flora and fauna), and the provision of visitor services and facilities (DoC 2005)

A twist in the tale

Interestingly, motivations for restoration have evolved to breed another rationale that is inclusive of ecological, legal, social & cultural reasoning. Over the last decade, the business sector has become increasingly preoccupied with 'sustainability' – looking at not simply economic performance as a business, but environmental and social performance as well. Performance measures include aspects such as emissions and waste production, resource use, staff and stakeholder wellbeing, and community engagement/social responsibility. There are a whole plethora of tools and resources available to help businesses improve their performance in these areas (e.g. www.nzbcsc.org.nz; www.sustainable.org.nz), with the intention of replacing the annual financial report with a sustainability or triple bottom line report. One of the business sustainability tools rising in popularity is ecological restoration planting.

Ecological restoration appeals as a sustainability tool because there are a number of perceived social and environmental benefits within the one activity including: support and engagement of local community restoration groups; a novel outdoor team-development opportunity for staff; a means to offset the business' carbon dioxide emissions, and; an opportunity to help restore a country's natural heritage and biodiversity. In addition, involvement in ecological restoration provides a great PR opportunity for the business to 'be seen' to be actively socially and environmentally responsible. In New Zealand, Honda is one such business undertaking restoration planting as a part of their overall sustainability plan. They have committed to plant 10 trees for every new vehicle sold – this amounts to about 60,000 trees per year - as a contribution towards taking responsibility for their own part in the global warming problem. Internationally, carbon neutral tree planting has been adopted by companies including BP, Sainsbury's, Avis and MTV. In addition to businesses, movie stars have also set the trend in adopting restoration plantings as a means to reduce their own personal carbon footprint. Leonardo De Caprio, Kylie Minogue and Sting are among many celebrities that have supported carbon neutral planting schemes in order to reduce their own impact on the environment.

The initiative has provoked intense skepticism from green extremes, with suggestion that it legitimizes behaviour that actually makes climate change worse by creating an illusion that tree planting 'neutralizes' fossil fuel use, i.e. that using fossil fuel is alright as long as a few trees are planted. Additionally, there are some flaws in the logistics of carbon neutral restoration planting, since trees only store carbon as long as they are alive, after which it is then released back into the atmosphere. Yet despite these technicalities, the socio-cultural and biodiversity values of restoration planting are reason enough to encourage participation in this initiative. Outside of these direct benefits, carbon-neutral tree planting schemes adopted by businesses and celebrities creates heightened awareness and increased environmental literacy among society about the environmental problems we are facing as a species. The effectiveness of publicizing such issues in this way is underestimated and it is perhaps the key to marketing and driving environmental behavioral change in the future.

The driving force behind it all

Delving further into the human condition may provide additional insight into why restoration has become more widespread in the last decade. Cairns Jr. (2002) aptly summarizes that "a primary reason for ecological restoration is to provide models of alternative, less destructive relationships between humans and natural systems" (p.10).

It is no mistake that as a species, our interaction with the natural world has been a largely destructive one (Bradshaw 2002). Our ever expanding demands to appease or improve our comfort and convenience have been at the expense of the planet and the increasing rate, intensity, and scale of ecosystem destruction is alarming. Ecological restoration is one of the few opportunities for humans to develop a less parasitic and more mutualistic relationship with nature.

Jordan (2003) explores this idea further to postulate that humans, as a community, need to ritualize the act of ecological restoration as a means by which to overcome existential shame – that is, the shame that we feel as a species when confronted with our destructive relationship with the environment. It is through the act of ecological restoration that Jordan believes we present a gift that allows us to deal with the shame of our violation of nature. By ritualizing the process of restoration - embodying it as a part of our culture - not only can we appreciate the beauty of our efforts, but also the intrinsic beauty associated with the process of ritual itself (Jordan 2003).

Wilson's (1984) *biophilia* hypothesis – that humans have an innate bond with nature - may be an important link to keep in mind if any serious consideration is to be given towards integrating ecological restoration as a ritual within cultures. In the same way that advertising has often used the innate connection that people have with one another to sell a product, by

the same token, the innate connection between people and nature may be a powerful tool for marketing restoration practice.

There is a large amount of literature supporting the notion that an innate anthropological-ecological bond exists. Wilson (1984) observes that more people go to zoos each year than attend professional sporting events. Other studies have shown how people can experience lower blood pressure, increased longevity, lower stress levels, and overall improved wellbeing through interaction with nature (Ulrich et al., 1991) and pets and animals (Katcher et al. 1984; Heerwagen 1990; Anderson et al. 1992; Friedman & Thomas 1995). As one environmental psychologist has written, "Nature matters to people. Big trees and small trees, glistening water, chirping birds, budding bushes, colorful flowers - these are important ingredients in a quality life." (Kaplan 1983, p.128). A study of office employees resonates with this thought, where employees reported that plants made them feel calmer and more relaxed, and that an office with plants is a more desirable place to work (Randall et al.1990). In urban settings, gardens and gardening have been linked to social benefits ranging from improved property values to greater conviviality (e.g., Patel 1990). Most importantly, it would appear that a nature *experience* (as opposed to observation alone) brings about a strong sense of connectedness to nature (Cumes 1998). The purported success of using nature experiences as a part of psychological therapy has been well documented (Jerstad & Stelzer 1973; Plakun et al. 1981; Witman 1987; Foster & Little 1989; Hartig et al. 1991; Greenway 1995).

These two ideas - that humans have an innate connection with nature and that nature experiences serve to improve human health and wellbeing - are important drivers for ecological restoration that need to be recognized. These innate drivers steer perspectives and objectives for restoration goals, defining the extent to which the activity is motivated towards ecological, legal, or social & cultural outcomes. Ecological restoration not only reinstates more natural ecosystems, but in itself provides a nature experience. The process is thereby an important means by which humanity can reconnect with the self and reduce the impact of a destructive relationship with nature.

1.2.2 The course of action: who and what is involved in ecological restoration?

Because ecological restoration is inherently practical, progression in this area of research will be highly dependent upon the learnings that can be drawn from current restoration projects (Harper 1987). In fact, Bradshaw (1987) takes this idea a step further to suggest that restoration is an 'acid test' of our understanding of ecology, that "there can be no more direct test of our understanding of the functioning of ecosystems than when we put back, in proper form or amount, all the components of the ecosystem we infer to be crucial, and then find that we have created an ecosystem that is indistinguishable in both structure and function from the original ecosystem, or the ecosystem that served to be our model" (p.27). Bradshaw uses the

analogy that, like a broken watch, if we are able to put an ecosystem back together and it functions again, then we know we have done the job correctly.

However, unlike the watch, there is no one right or wrong way of restoring an ecosystem – there may be any number of species, including exotics, which could serve the same functional role in an ecosystem. For example, while the New Zealand North Island Brown Kiwi *Apteryx mantelli* inhabits indigenous forest in the Hawkes Bay, it also lives in exotic *Pinus radiata* forests in Northland, Coromandel, Bay of Plenty and inland Taranaki (Potter 1990). This is interesting because pine forests do not have much undergrowth and generally produce an environment which is quite different from that within native forest. Similarly, the New Zealand Mahoenui Giant Weta *Deinacrida "Mahoenui"*, thought to be extinct, was rediscovered in 1962 in a patch of King Country gorse *Ulex europaeus* - a common weed species in New Zealand (Watt 1963). This habitat is distinct from the native forest floor debris that *Deinacrida* are understood to inhabit, but the spiny *U. europaeus* serves to protect the species from predators. These two examples illustrate how exotic plant species can undertake the function of primary producers and provide habitat for native species. Therefore, a restored system may still serve the 'function' of the reference ecosystem without accurately resembling the structure. Whether one is more 'correct' than another is a question of perception that will largely be dependent upon the goals of the project at the outset.

Therefore, restoration efforts should focus on imitation rather than item-for-item reproduction of the reference ecosystem (Jordan et al. 1987). Imitation means being able to create communities that resemble other communities in function, but that may actually differ from them in species composition. This may be a more attainable goal for restorationists given the extent to which habitats have been modified and the context within which they are being restored. The latter point is important to keep in mind since interaction of ecological processes is not limited to the scale or parameters of the restoration project site; to expect to restore an indigenous un-disturbed forest community item-for-item within an urban context may be somewhat unrealistic.

The New Zealand restoration context

Unfortunately, this is often a desirable condition that many restoration projects in New Zealand aspire to. For example, the Mana Island Restoration sets out to "recreate coastal forest, shoreline and wetland plant communities...similar to those likely to have occurred on the island before human contact" (DoC 1997i, p.5). Similarly, the management vision for Moutohora Island seeks to restore "ecosystems and species groupings close to a pre-human state" (DoC 1997ii, p.1). Ecological restoration in the context of Somes Island implies "the restoration of biotic communities to a former condition" (DoC 1996, p.13). These cases, as

well as other examples of New Zealand restoration projects are examined further in Chapter 2.

Outside of the context of islands and urban areas, where restoration is usually of degraded or depleted fragment ecosystems, management also occurs at the other end of the continuum on areas of land that have had more dramatic modification e.g. through quarrying, mining and landfill. Between these two extremes, retired agricultural pasture is another common land type in New Zealand where restoration management takes place. Land may be retired from agricultural practice because it has been overgrazed and is therefore unfit for further use in the immediate term. Ecological restoration may help the soil structure and fertility to recover and may also serve to enhance the quality of adjacent farmland.

The types of ecosystems that restoration managers are commonly attempting to restore include native forest, wetland systems, riparian margins, lake and marine ecosystems, dunes, tussock grasslands, islands, and alpine ecosystems.

In New Zealand, the groups of people involved in restoration activity include: researchers, conservationists, landscape architects, developers, community groups, non-government organisations, schools, local authorities, crown research institutes (e.g. Landcare Research), public organisations (e.g. Department of Conservation), farmers, and individuals. There are over 2,500 public and private projects in progress across the country (Mike Peters pers comm. 2004) and many of these have limited resources available to keep the momentum going. The process of restoration is largely driven by human intervention and therefore the success of many projects is often dependent upon the investment made by dedicated volunteers and supporters. These issues are explored further in Chapter 4, which presents the results of focus group research undertaken with New Zealand restoration practitioners.

1.2.3 The Complications and Challenge: a silver bullet for restoration?

The lack of available data on restoration cases, as well as the inconsistencies in restoration planning, methodology and monitoring, are issues not limited to the New Zealand restoration context (Choi 2004). Pastorak et al. (1997) speculate that many restoration projects completed so far have been planned on an ad hoc, consensus basis and no standard methods are available (Cairns 1988; MacMahon & Jordan 1994; Sweeney 2000). Inadequate site surveys and projects deficient of a management plan, or even clearly stated objectives, have been cited as reasons for project failure in the past (Harris et al. 1996; Kentula 2000; Quammen 1986). Effective planning is critical for restoration projects to maximise the overall success of efforts and minimise costs (Hobbs & Norton 1996).

However, the difficulties that have been associated with planning and adaptively managing restoration projects in the past may result from problems in understanding the ecosystem in

the first place. Outside of the fact that there are gaps and contradictions in the vast body of reference ecosystem data that is available, there is a large degree of uncertainty regarding spatial and temporal variability in natural conditions such as hydrology and weather, as well as the ecological impacts of restoration management on natural variation in growth and reproduction of plants and animals – the net result being that the capacity to predict specific restoration outcomes is limited (Thom 2000).

Ironically, it may be possible that ecological models predicting species' patterns of distribution, abundance and coexistence are not even relevant. Hubbell's (2001) theory of neutrality assumes that species do not exploit a niche and instead compete equally for the same pot of resources. Thus, the identity of a tree that fills the gap in a canopy is a consequence of random dispersal, birth and death of individuals, and the total number of organisms in the community. The most startling revelation of this research is that Hubbell's neutrality model results in near-perfect recreations of natural communities (Whitfield 2002). This raises some very important questions about the credibility and usefulness of predictive ecosystem modelling and adds weight to the idea that the outcomes of ecological restoration are not deterministic (Mitchell 2002; Suding 2004). Chapters 3 and 5 explore these theoretical challenges further.

Confounding factors

Many of the anomalies in existing ecological and restoration data can be explained by the 'ad hoc' methodologies carried out to collect and analyse the data. This is partly a function of the diversity of goals associated with the many and varied groups involved in ecological restoration but moreover, a lack of understanding ecology itself. These theoretical black holes mean that restoration practice involves experimentation not only to see how to fix a system, but how it works in the first place. Thus, ecological theory to restoration should be seen as a collection of hypotheses that are subject to scrutiny, rather than a set of infallible ideas to be verified. This idea is not a new one (e.g. Bradshaw 1987; Jordan et al. 1987; Harper 1987), though it should be emphasised that if testing ecological theory is to take place in restoration, serious consideration needs to be given towards developing some rigorous methods to do this, since restoration, unlike a lab experiment, usually involves multiple objectives and is not always undertaken by scientists. Therefore, it is pertinent that rigorous methods are developed for testing ecological theory in restoration since the consequences of a 'failed' restoration experiment may not just be on the experimenter. Where restoration involves community or government support, or collaboration with others, consideration needs to be given towards meeting the needs of these groups as a part of the experiment. This includes incorporating legal/social objectives and also facilitating a common understanding regarding the 'nature' that is to be restored, since perceptions of what constitutes 'nature' are many and varied.

Higgs (2003) suggests that as technology such as internet, email, and electronic games have moved people more indoors, our perceptions of 'nature' have also shifted and become influenced by the virtual information and experiences that such media presents. Higgs' description of the Disney Wilderness Lodge is an example of the dichotomy between the wilderness that actually exists and the idealistic 'virtual wilderness' that Disney presents to visitors. Further, if 'felt experience' creates ecological literacy (Orr 1992), then the impact of places such as the Disney Wilderness Lodge in shaping people's perceptions of the natural world is somewhat disturbing.

A consequence of the above is not only a difference in opinion about what needs to be restored, but also, what constitutes restoration. 'Restoration' occurs in all manner of practices including reclamation, conservation, and landscape design. Jordan (1987) even identified restoration as a form of gardening due to the social aspect of the process. Restoration may not necessarily follow orthodox methodology either; for example, an experiment in Grand Canyon National Park found prescribed fire burning to be more effective than active planting in restoring pre-European settlement forest (Fule et al. 2004). Thus, a restoration definition needs to cover the range of activities within which it occurs and there needs to be some clear assumptions about the goals of restoration that can accommodate a diversity of management techniques. This area will be covered further in section 1.3 below.

To summarise the complications that are presently being faced in the field of restoration ecology; the limited amount of restoration data available is difficult to draw insight from and this may be partly due to the inconsistent methods employed for collecting data and assessing restoration progress. A lack of an understanding of ecosystems in general may explain the novel and experimental approaches taken in ecological restoration and this is confounded by the diverse goals and participants in a given project and perceptions of what 'nature' and 'restoration' actually are.

The Challenge

Given the above, it may be unrealistic to expect that there is a 'silver bullet' or a single best practice model for ecological restoration, but if we are going to progress a more pragmatic approach to the discipline, developing standardised definitions and data collection methodologies are an important first step. By facilitating a more unified approach in these areas, we can develop clearer communication and understanding and increase our capacity to compare outcomes between restoration projects.

1.3 Definitions

1.3.1 Historical context

Although restoration ecology as a field of scientific enquiry is little more than two decades old the practice of ecological restoration has been around for much longer and restoration as a term has been used to describe a variety of different operations and objectives (Bradshaw 2002).

Within much of the restoration literature to date, definitions for ecological restoration have emphasised either: goal-oriented restoration, concentrating on reconstructing functioning ecological systems, or; process-oriented (biocultural) restoration focusing on the integration of ecological principles and human social systems (Cairns & Heckman 1996). Early definitions of ecological restoration generally reflect the goal-oriented view (e.g. SER 1990 – cited in Higgs 1997; National Research Council 1992; MacMahon & Jordan 1994; Harris et al. 1996), while more recent definitions accommodate the holistic, process-oriented focus (e.g. Jackson et al. 1995; Wyant et al. 1995; Society for Ecological Restoration (SER) 2004).

Interestingly, the definitions for related ecological practices such as remediation, reclamation, rehabilitation, and revegetation have been less contentious and remain more consistent throughout the literature (Francis et al. 1979; Cairns & Heckman 1996; Sweeney 2000; Bradshaw 2002; Higgs 2003; SER 2004).

There is a need for unanimity in the definitions and terminologies used in restoration ecology in order to promote adequate understanding and practice of restoration. Further, an ecological restoration definition needs to incorporate social, cultural, aesthetic, economic, political and moral values in order to include and gain acceptance from the wider range of stakeholders that have traditionally been employed in ecological restoration (Wyant et al. 1995; Szaro et al. 1998).

1.3.2 The issue of scale

There have been many attempts in the past to develop standardised ecological terminologies and definitions; however, even the most seemingly robust and useful of these have been made conditional by the scale of the observation (Allen & Hoekstra 1987; Beeby 1993). If scale creates confusion at the level of definitions and terminologies then this will surely manifest in a variety of interpretations for appropriate methods to collect and interpret field

data and subsequently, impact upon the development of sound conceptual models (Parker 2001).

Indeed, spatial scale has long been a point of debate in the application and effectiveness of predictive ecological models (Loucks 1970; Wright 1974; Whittaker & Levin 1977; Costanza & Maxwell 1994; Freckleton 2004). This may be explained by the fact that large scale ecological patterns take much longer to change and are therefore more predictable than those on smaller scales, which respond more readily to subtle abiotic variation. For example, at a large physical scale, such as the eastern U.S., it is entirely reasonable to suggest that successional pathways will likely produce the equivalent of a climatically-controlled climax vegetation recognisable as the eastern deciduous forest biome; deserts and grasslands are unlikely to occur there without large-scale climatic shifts. However, as the spatial scale of resolution decreases, the certainty of predicting the eventual outcome of succession decreases as does the self-maintaining nature of these later stages. Thus, the climax concept becomes less feasible as site factors and recurrent disturbance become more important at scales below the biome (Allen and Hoekstra 1992).

Temporal scale has also been an issue in definitions of ecological restoration, particularly for earlier definitions which focused on reinstating an 'historical ecosystem' or return to a past ecological condition. The most hotly debated concern traditionally being: what target historical community are we trying to restore (Bradshaw 2002)? Ecological complexity and natural variability, the effects of global climate change, and loss of habitat, species, and genotypes must all be considered. This means the modern or recent past, or even the 'pre-contact' state, may not always be the appropriate target for restoration. Callicott (2002) proposes that as a function of the 'flux of nature' paradigm in ecology, reference sites are constantly changing and are essentially moving targets. If the reference ecosystem is continually evolving, is it even feasible to set goals for an 'end-point' set of conditions in restoration projects? While the process of restoration continues to involve assisting the recovery of *an ecosystem* that has been damaged, degraded, or destroyed, there will always be the need for *an ecosystem* reference that is considered to be 'un-damaged', 'un-degraded', or 'un-destroyed', despite modern definitions of ecological restoration favouring a process-oriented perspective. Egan & Howell (2001) attempt to address some of these issues in their book *The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems*, which provides tools to help practitioners and academics understand the composition of former communities.

Therefore, in order to establish a meaningful (and standardised) approach to restoration ecology, spatial and temporal scale are extremely important factors that should be explicitly noted in any guiding theory or published case example – almost like a disclaimer.

1.3.3 Definitions and terminologies in this thesis

As a function of the diversity of interpretations available for ecological terminologies such as 'restoration', the following section provides a summary of the definitions associated with common terminologies referred to in this thesis.

This thesis adopts many of the definitions outlined in *The SER International Primer on Ecological Restoration*, published by the Society for Ecological Restoration International Science & Policy Working Group (SER 2004). The Society for Ecological Restoration is at the forefront of supporting, co-ordinating, integrating and publishing theoretical and practical research in ecological restoration on an international scale. Furthermore, members of the SER International Science and Policy Working Group are independently renowned and respected for their contribution to the evolution of restoration ecology as a scientific discipline (e.g. James Aronson, André Clewell, Keith Winterhalder, Eric Higgs, Richard Hobbs, and James Harris). Their collaborative effort in the *Primer* represents the culmination of informed thought resulting from a diversity of international field experience and research in ecological restoration.

Therefore, in the interests of respecting the wisdom of the SER and also in promoting a consistent international understanding and approach to Restoration Ecology, the terminologies used in this Thesis resonate the definitions outlined by SER (2004).

Table 1 below summarises the *most common* ecological terminologies used in this Thesis. For all other ecological terms referred to in the subsequent six chapters that are not included in the glossary below, it should be assumed that the definitions of these are consistent with those of SER (2004).

Table 1: Glossary of Common Terminologies and Definitions used in this Thesis

Terminology	Definition
Ecological processes or ecosystem function*	The dynamic attributes of ecosystems, including interactions among organisms and interactions between organisms and their environment.
Ecological restoration*	The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.
Ecological theory	The rules, concepts, research, literature, principles and models that underpin ecology as humans perceive.
Ecological trajectory*	A trajectory that describes the developmental pathway of an ecosystem through time.
Ecology	The scientific study of the distribution and abundance of living organisms and how the distribution and abundance are affected by interactions between the organisms and their environment. (http://en.wikipedia.org/wiki/Ecology)
Ecosystem*	The biota (plants, animals, microorganisms) within a given area, the environment that sustains it, and their interactions.
Reclamation*	A return of the land to what, within the regional context, is considered to be a useful purpose.
Rehabilitation*	The reparation of ecosystem processes productivity and services.
Restoration Ecologist	One who investigates the science of restoration ecology.
Restoration Ecology	The study of renewing a degraded, damaged, or destroyed ecosystem through active human intervention. (http://en.wikipedia.org/wiki/Restoration_ecology)
Restoration Practitioner	One who undertakes the practice of ecological restoration.
Revegetation	The process of replanting and rebuilding the soil of disturbed land. (http://en.wikipedia.org/wiki/Revegetation)

* Denotes term defined by SER (2004)

1.4 Assumptions

An assumption is “a proposition that is taken for granted, in other words, that is treated for the sake of a given discussion as if it were known to be true.” (<http://en.wikipedia.org/wiki/Assumption>). In restoration ecology and indeed in most disciplines of science, where theoretical gaps exist then assumptions need to be made in order to progress research, practice and experimentation. Assumptions can be turned into research hypotheses, or where enough empirical evidence exists to support an idea then it becomes a fixed assumption embedded in the research. It may be unreasonable to develop any fixed assumptions in ecology, where one ecological phenomena can often be explained by multiple evidence-based theories (e.g. succession: monoclinal theory [Clements], polyclinal theory [Tansley], climax-pattern theory [Whittaker], and non-equilibrium hypotheses).

If Bradshaw's ‘acid test’ concept is appropriate for ecological restoration then this implies that all ecological theories to date are in fact ‘assumptions’, rather than ‘rules’ in their relevance to restoration ecology. All applied ecological concepts should therefore be treated as research questions in their application to ecological restoration. This seems rather obvious, and there are some good case examples of restoration projects receiving this kind of experimental treatment, such as the Kissimmee River restoration project (Harris et al. 1995; Koebel et al. 1999) and the University of Wisconsin-Madison Arboretum restoration experiments (e.g. Streever & Zedler 2000; Lindig-Cisneros & Zedler 2002). However, these examples are a minority as there very few restoration projects currently incorporating scientifically experimental methods in their implementation (Choi 2004).

Therefore, ecological assumptions are unwittingly embedded in the goals and objectives of every restoration project – why would one aim for a target restored community if they didn't assume that it could be achieved? The very notion of restoration – that humans can assist the recovery of an ecosystem – is in itself a huge assumption. There is certainly evidence in the form of perceived ‘unsuccessful’ projects that supports the idea that restoration does not assist any clear directional changes toward a target community (Briggs et al. 1994; Simenstad & Thom 1996; Zedler 1996; Zedler & Callaway 1996).

Several other key un-tested assumptions are rooted in the foundation of restoration ecology; (1) That the physical environment can be manipulated to support the desired plants and animals (Palmer et al., 1997); (2) That inadequate substrate can be manipulated to sustain native biota; (3) That a restoring ecosystem can follow the same trajectory of development as an historical reference ecosystem, and; (4) That an ecosystem undergoing restoration will eventually become ‘self-sustaining’.

These assumptions concern every component of the ecosystem, stressing the need for interdisciplinary approaches to improve the effectiveness of restoration efforts. The expertise to test these broad assumptions need to come from hydrology, soil science, plant and animal ecology, forestry, conservation biology, and landscape ecology. But ecological restoration is not simply a bio-physical process devoid of human effect. Actions by people are and always have been a major historical factor shaping ecosystems everywhere, and human behaviour ultimately determines the success or failure of restoration efforts (Langston 1998; Harwell 1998). Therefore it is critical to understand the role of human behaviour, but more importantly, to create social and bio-physical tools and protocols that can be used to promote successful and sustainable restoration projects. Hence, sociology and ecological economics must be added to the list of disciplines needed to make advances in whole-ecosystem restoration (Costanza 1996, Folke et al. 1996).

1.5 Summary & Scope of this Research

This chapter has endeavoured to provide a general introduction to restoration ecology as a foundation to the research that follows in subsequent sections, which broadly aims to investigate the place of ecology in restoration ecology. Specifically, research objectives seek to: (a) examine the current treatment of ecological theory in the restoration guidance available for practitioners and its application in New Zealand restoration case examples; (b) explore whether ecological theory can provide more direction for restoration ecology, and; (c) test the theoretical and practical value of a conceptual ecological model (Odum 1969) as a form of guidance for New Zealand restoration practitioners.

The dynamic sociological and ecological complexities presented in this chapter exemplify restoration ecology as a special kind of science and have been the source of inspiration for this piece of research, which attempts to forge a greater understanding of the balance and interaction of the two. Thus, it is with this context that this Thesis investigates the place of ecology in restoration – with the appreciation that restoration outcomes are a bi-product of the mutual coalescence of people and ecology.

Ironically, by focusing on the place of ecology in restoration, it is hoped that this will serve to emphasise the differences between ecological restoration and applied ecology and to inadvertently highlight the place that people have in restoration ecology. This process may provide further insight into why some restoration projects may have perceived to have been more successful than others and also serve to strengthen restoration concepts, terminologies and definitions. This thesis seeks to enable the reader to identify pragmatic methods for understanding how to best progress restoration as an amalgamation of sociological and ecological goals without compromising the integrity of either.

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Chapter 2

What place does ecology presently have in the theory and planning of ecological restoration?

2.1 Introduction

Bradshaw (1987) proposed that ecological restoration provides another means by which to test (and verify) ecological theory – that a successful restoration means an ecological understanding has been proven. Unfortunately, this methodology has not developed much further than the conceptual stage; initial progress in this area will require the development of rigorous methods for undertaking such an experimental approach. In addition, this acid test may not necessarily shed light on which ecological theories are most accurate or relevant, since it is likely that evidence can be gathered to support all theories, or even serve to create more.

However, despite a lack of formal procedure for understanding how ecology fits into the restoration picture, the practice of ecological restoration has not been inhibited. Increasing awareness of global environmental issues and tighter environmental legislation have boosted the number of restoration projects taking place around the world.

The mixed success of restoration actions emphasises the urgency to improve methods for understanding and utilising ecological theory as a reference for more effective ecological restoration. The first part of this chapter investigates how ecology – which collectively refers to ecological theory, models and concepts – has been disseminated within the current restoration guidelines available to practitioners. ‘Guidelines’ provide restoration practitioners with direction on planning, implementing and evaluating restoration projects. These guidelines should represent practical recommendations that have been formulated as a product of research in ecology, restoration ecology and historical case data (from both applied ecology and ecological restoration).

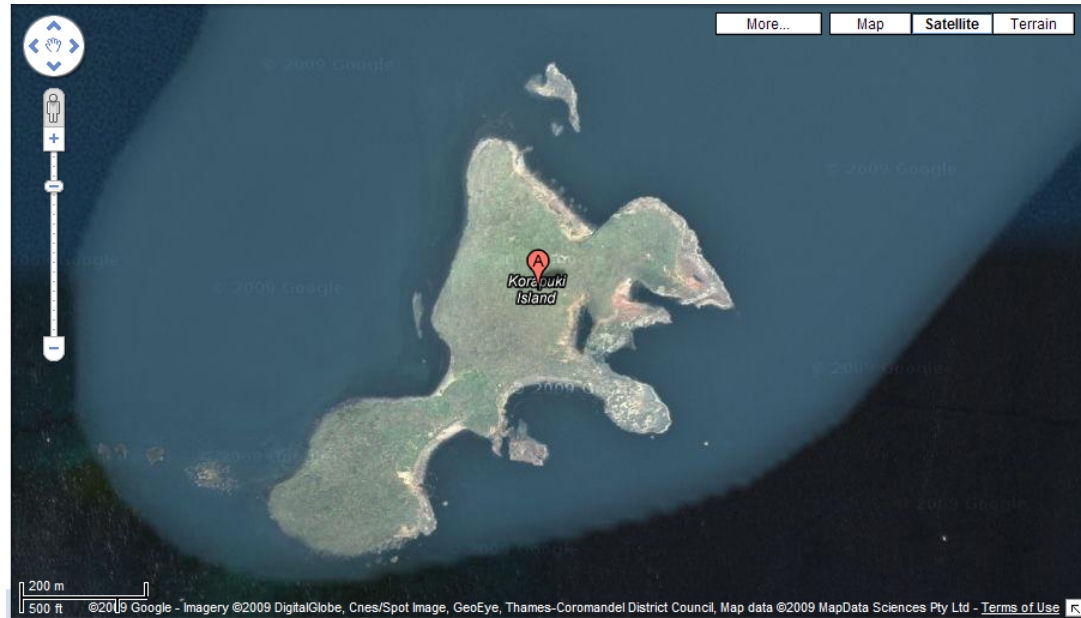
In the second part of this chapter, an assessment of New Zealand (NZ) restoration case examples is undertaken to identify how practitioners incorporate ecology within actual restoration project plans, and whether there are gaps between theory and planning.

2.2 Methodology

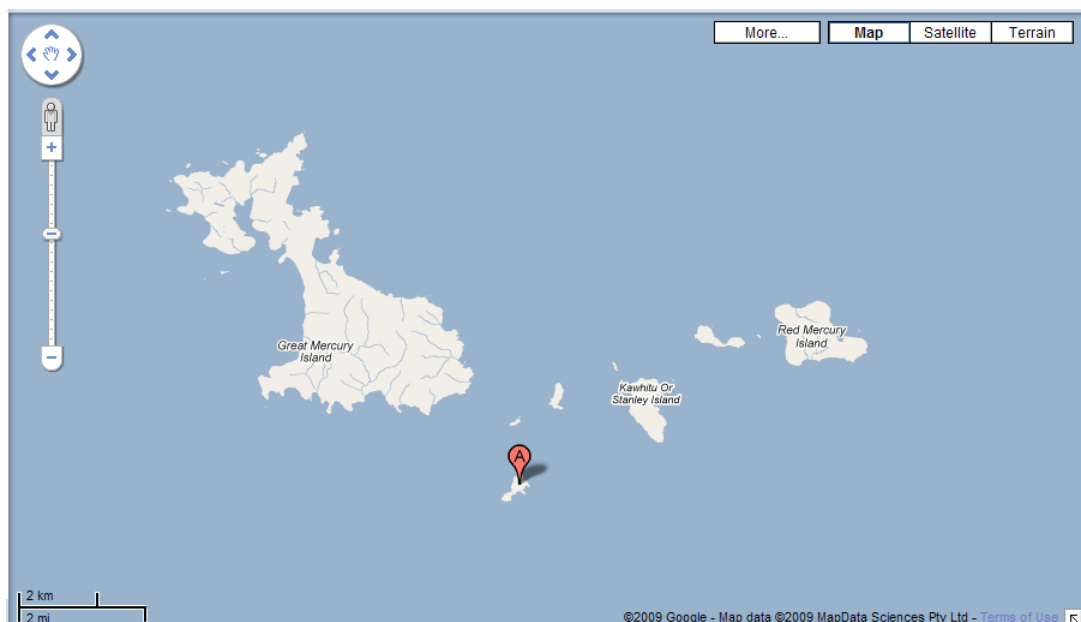
1. An initial literature search was undertaken to identify the ecological restoration guidance available for New Zealand restoration practitioners. The following publications were identified:
 - Guidelines to the Development and Monitoring of Ecological Restoration Programmes (Atkinson 1994.)
 - Guidelines for Developing and Managing Ecological Restoration Projects (Clewett et al. 2000).
 - Protecting and restoring our natural heritage: a practical guide (Davis & Meurk 2001).
 - Landscape restoration handbook (Harker et al. 1993).
 - Handbook of Ecological Restoration – Volumes 1&2 (Perrow & Davy 2002)
 - Native Forest Restoration: a practical guide for landowners (Porteous 1993).
2. Relevant New Zealand (NZ) restoration project plans were selected from sites restoring different habitat types (e.g. coastal, forest, island, wetland, mainland island) implemented by different practitioners within the New Zealand restoration sector (e.g. community groups, crown research institutes, regional authorities). These included the following sites:
 - Korapuki Island (Mercury Islands) (Figure 1)
 - Lake Wairarapa Wetlands (Figure 2)
 - Tiromoana Bush, Canterbury (Figure 3)
 - Caversham Valley, Dunedin (Figure 4)
 - Maungatautiri, Cambridge (Figure 5)
 - Olympic Park, Auckland (Figure 6)
3. Restoration guidelines and NZ restoration project plans listed in (1) and (2) above were assessed across three dimensions: Planning (goals, objectives, and methodology selection); Implementation (techniques for restoration), and; Evaluation (monitoring and assessing progress).
4. Criteria for assessment:
 - a. Investigate how ecology is weighted amongst other restoration objectives (social/cultural/economic).
 - b. Identify whether ecological focus in restoration guidelines/plans is directed towards structural and/or functional success.
 - c. Using Young et al.'s (2005) list of ecological concepts (Table 2), examine whether these have been incorporated within restoration guidance/plans and if so, how.

Figure 1: Satellite view of Korapuki Island (i) and maps (ii, iii, iv) showing the island's location (A) in New Zealand (from Google Maps)

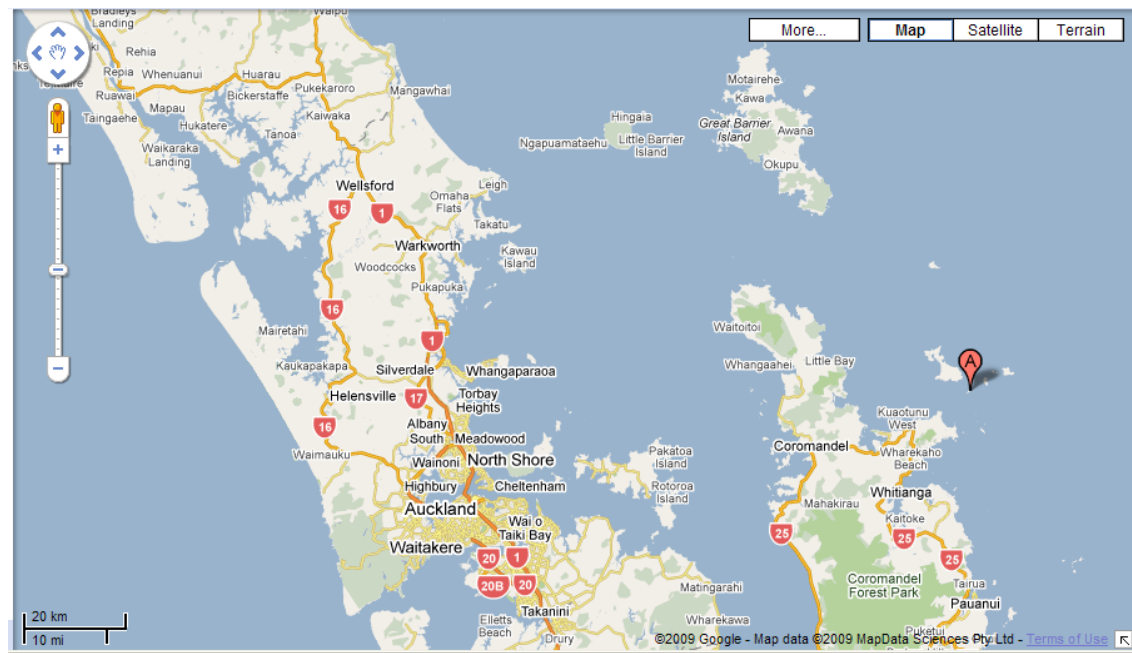
(i)



(ii)



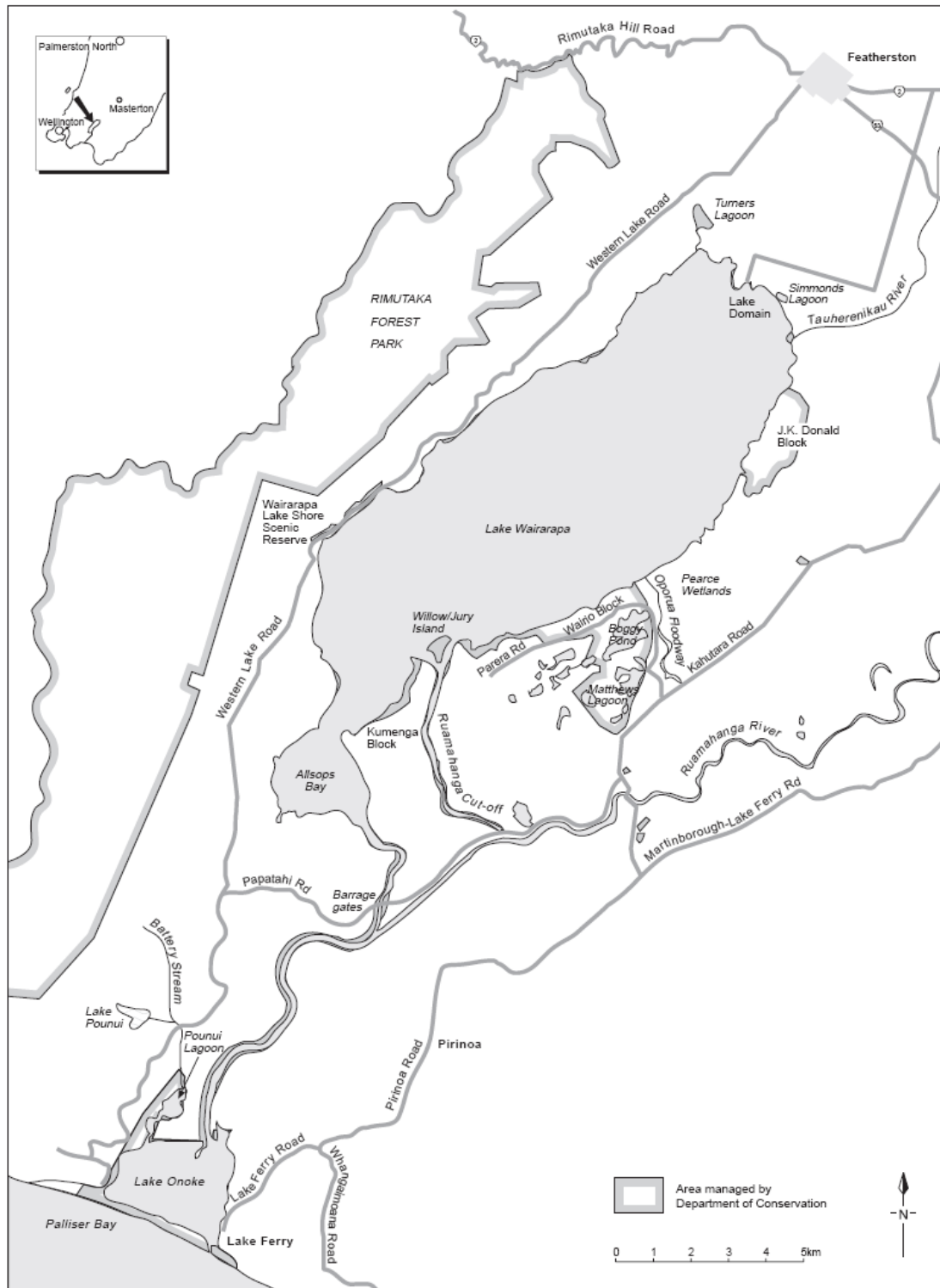
(iii)



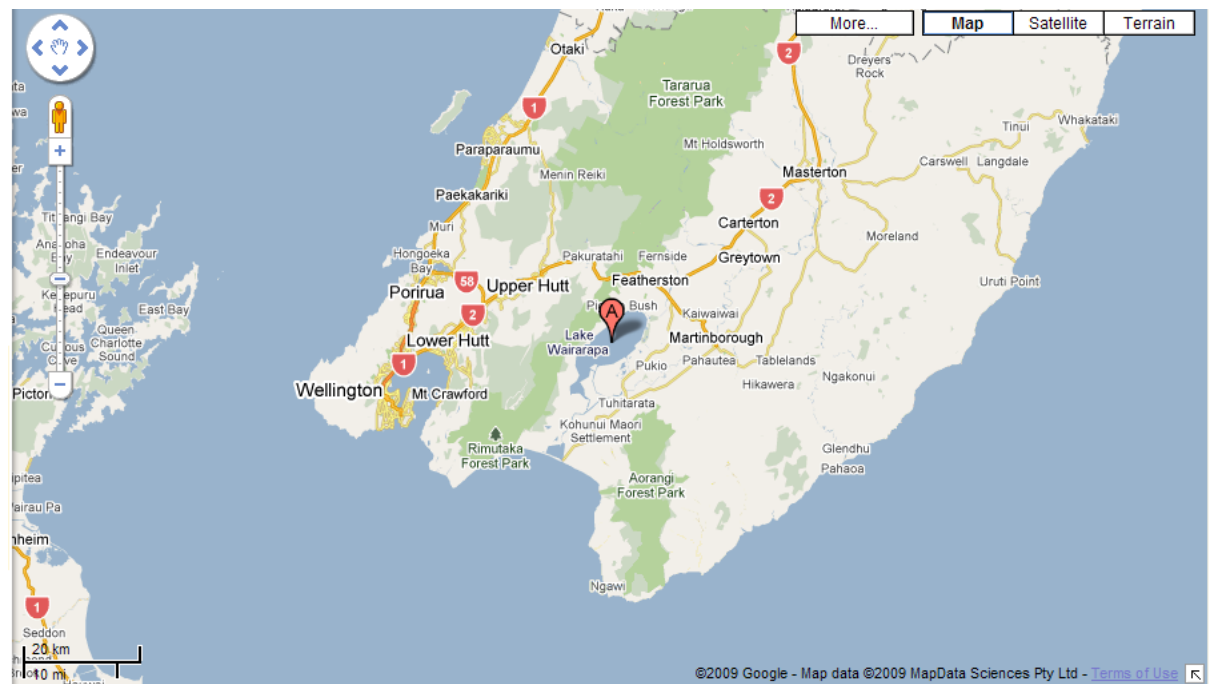
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Figure 2: Map of Lake Wairarapa Wetlands, Wairarapa, North Island, New Zealand (i) (from DoC 2000), and; maps (ii, iii) showing location of Lake Wairarapa (A) in New Zealand (from Google Maps)



(ii)



(iii)

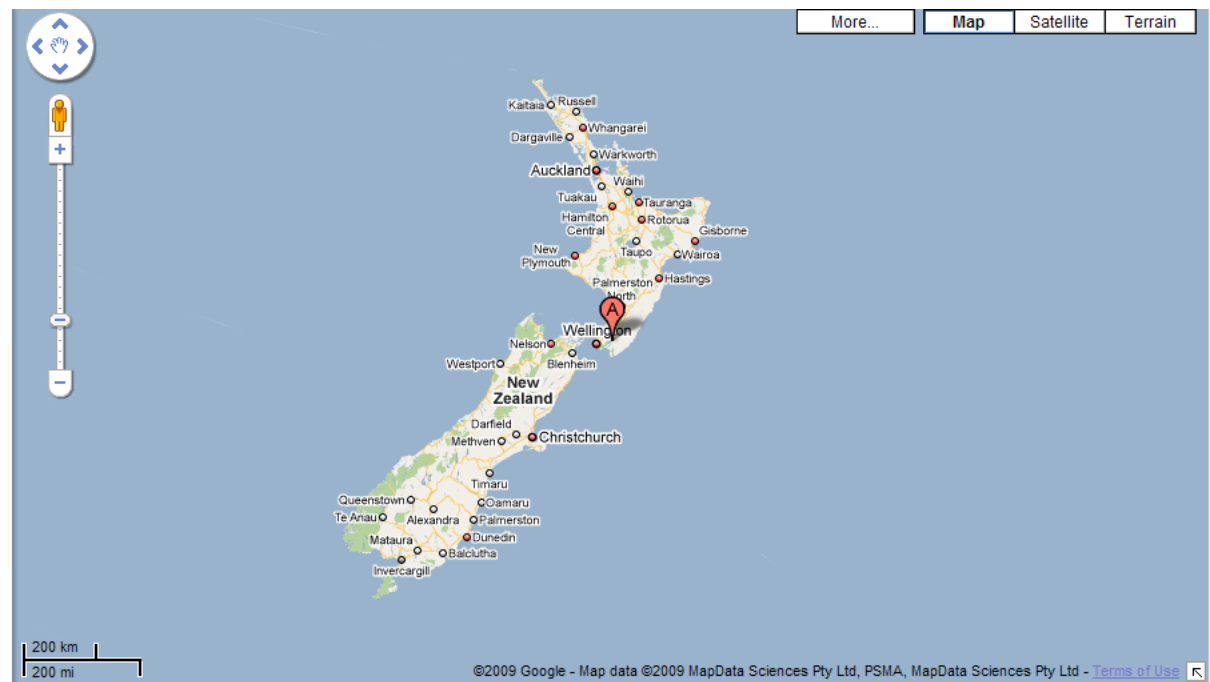
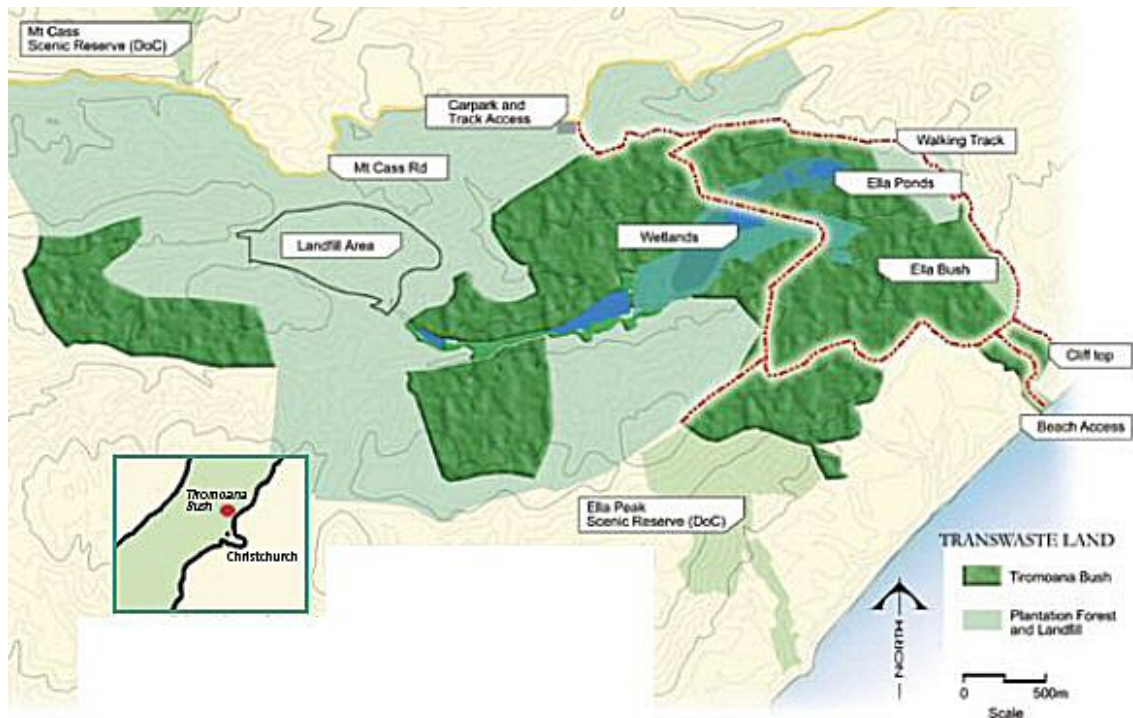
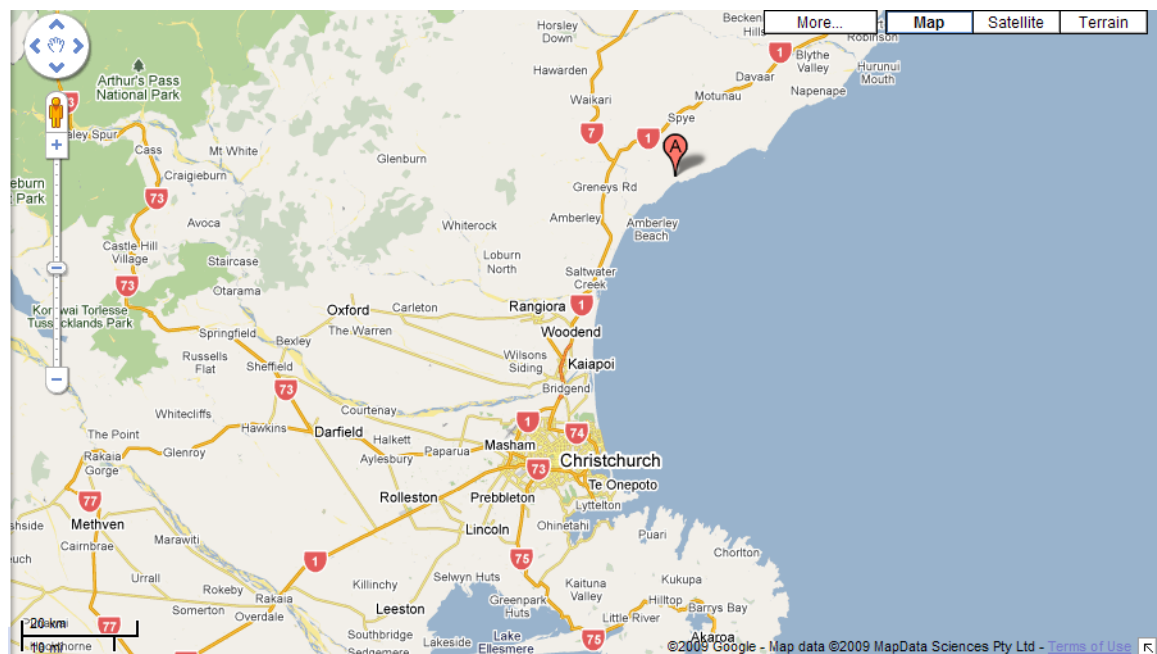


Figure 3: Map of Tiromoana Bush, Canterbury, South Island, New Zealand (i) (from Norton 2005), and; maps (ii, iii) showing location (A) of Tiromoana Bush in New Zealand (from Google Maps)

(i)



(ii)



(iii)

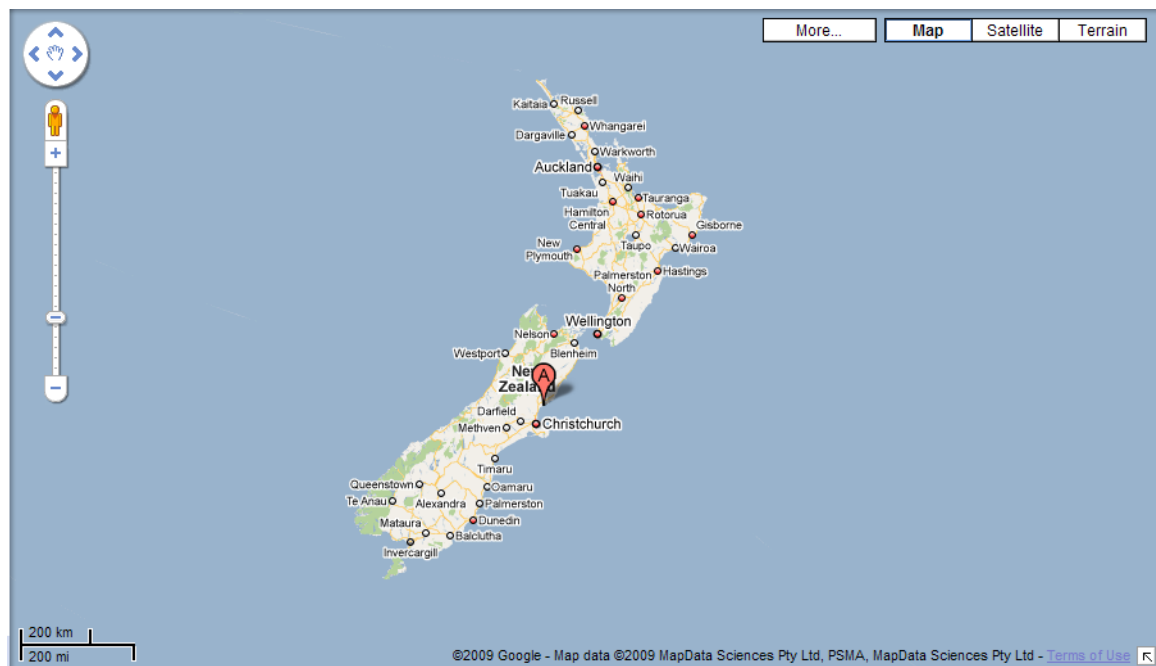
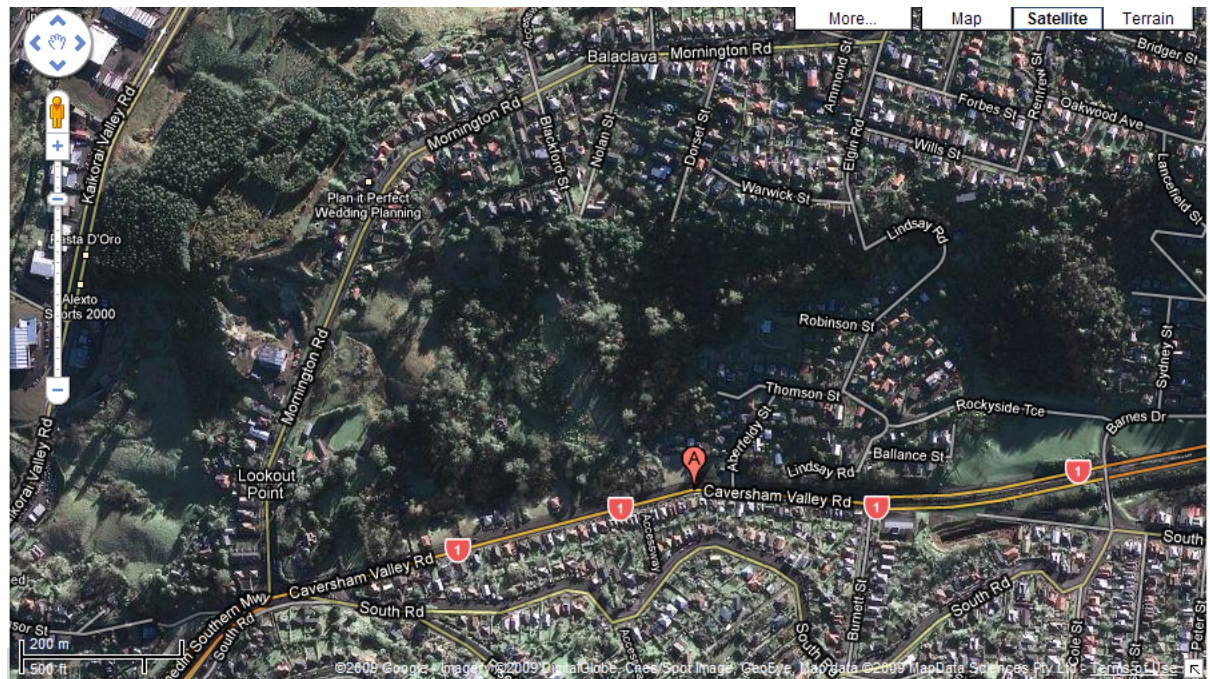
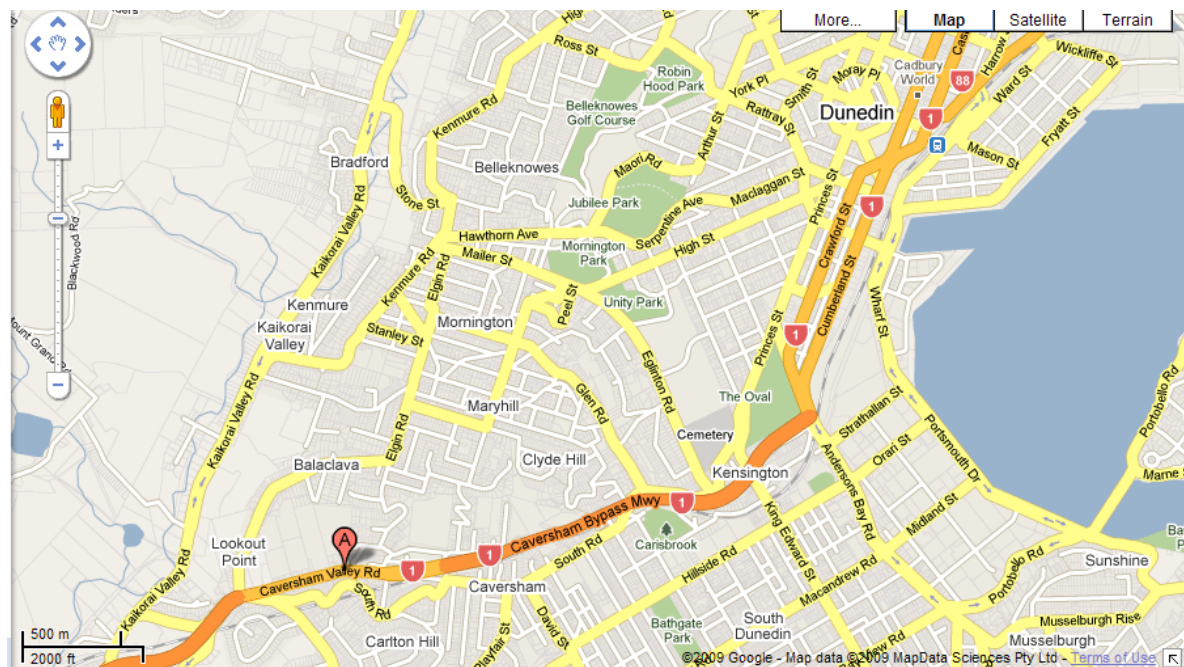


Figure 4: Satellite map of Caversham Valley, Dunedin, South Island, New Zealand (i) and maps (ii, iii, iv) showing its location (A) in New Zealand (from Google Maps)

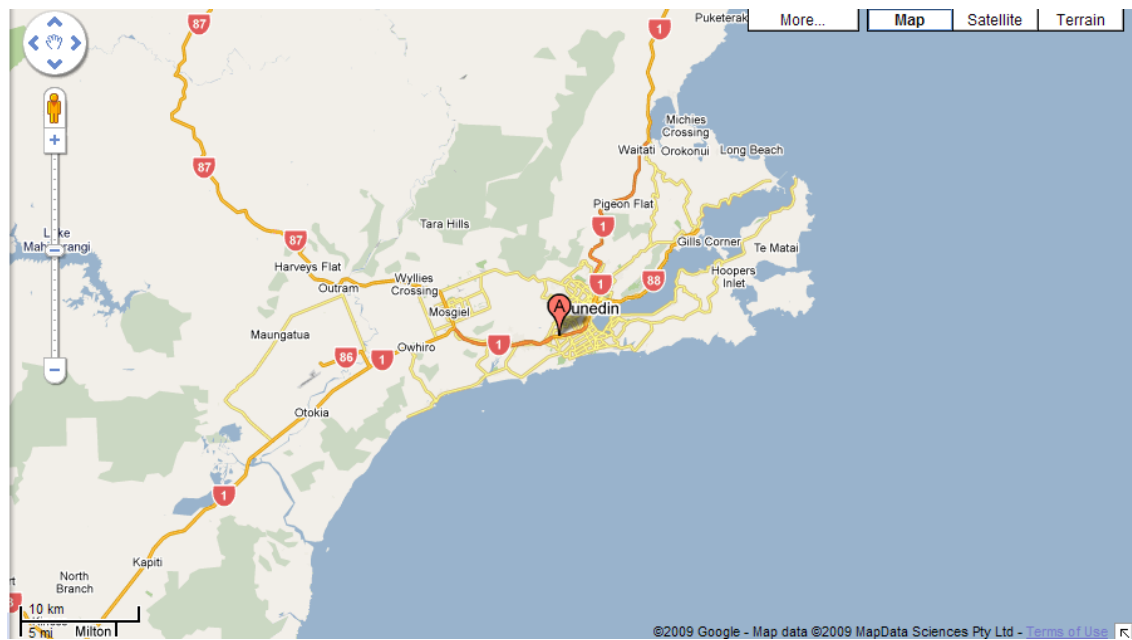
(i)



(ii)



(iii)



(iv)

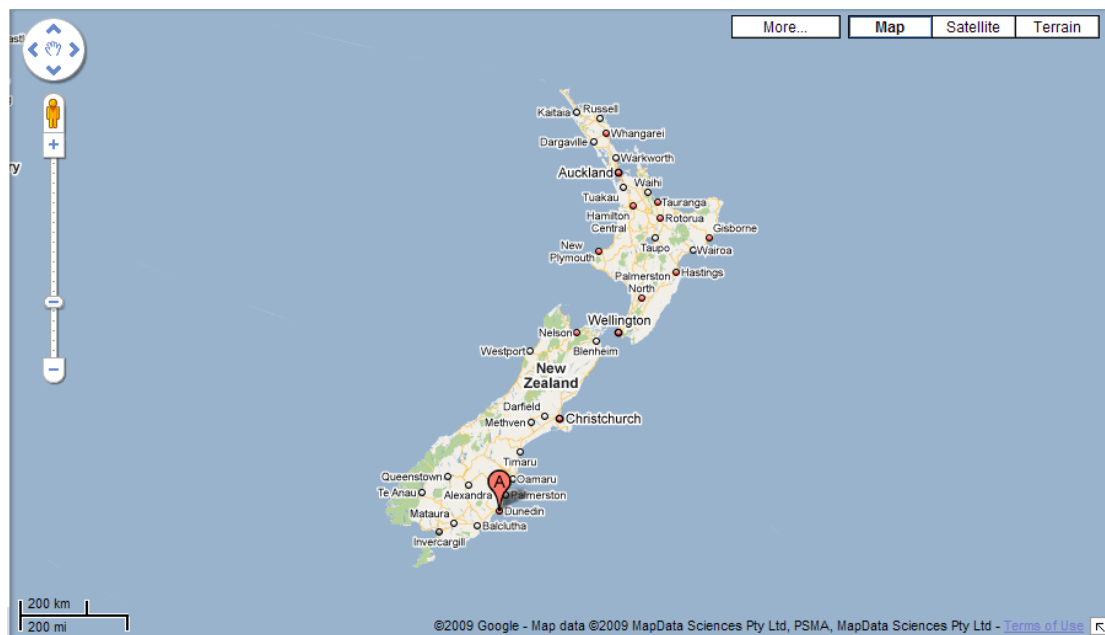
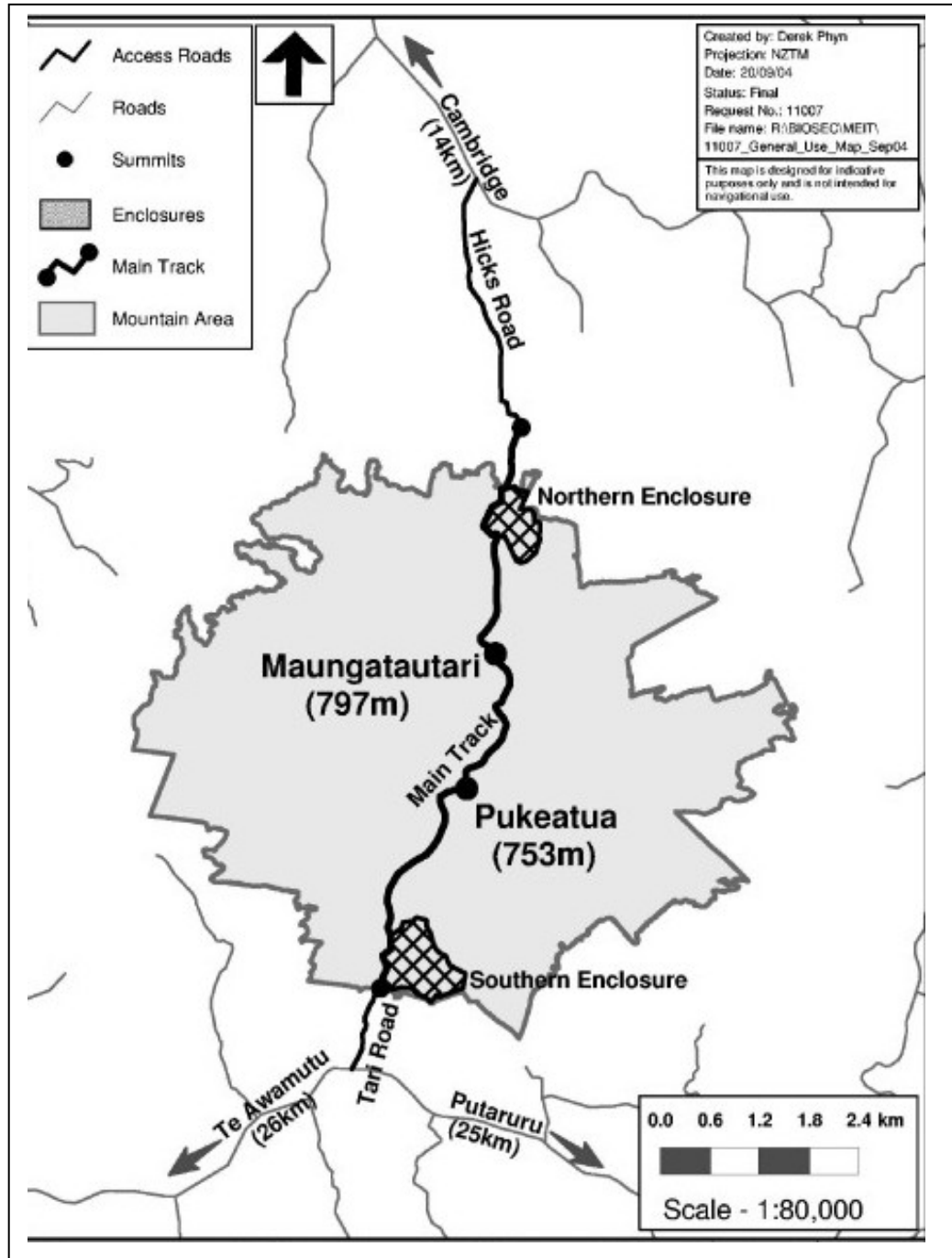


Figure 5: Map of Maungatautari, Cambridge, North Island, New Zealand (i) (from McQueen 2004), and; maps (ii, iii, iv) showing location (A) of Maungatautari in New Zealand (from Google Maps)

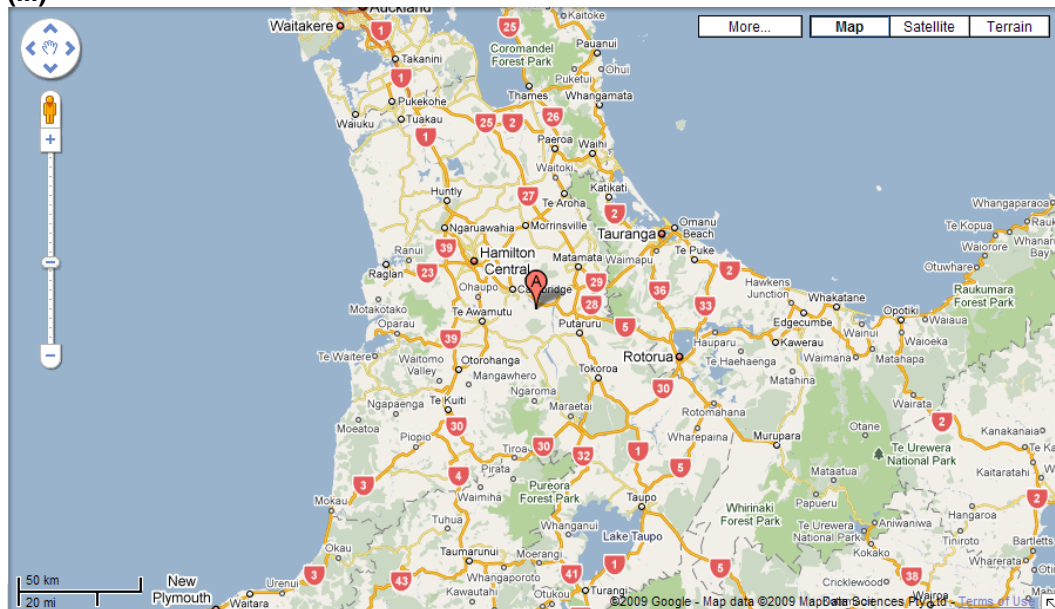
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(ii)



(iii)



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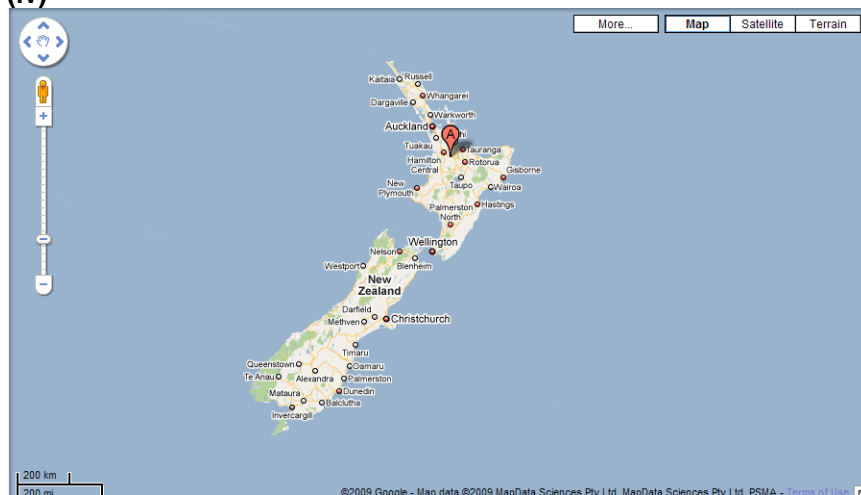
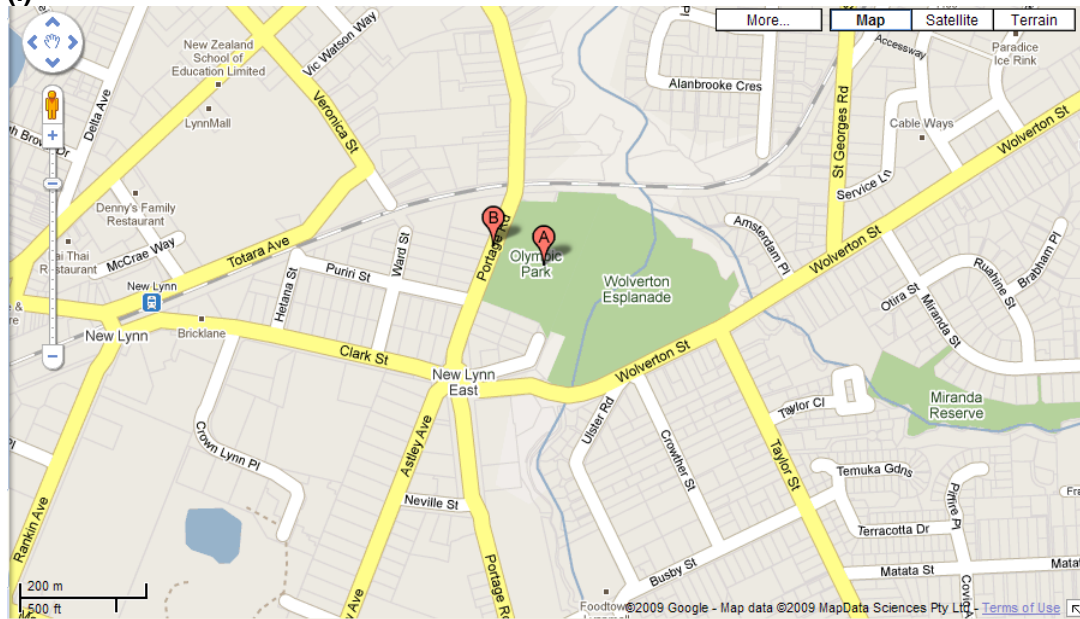
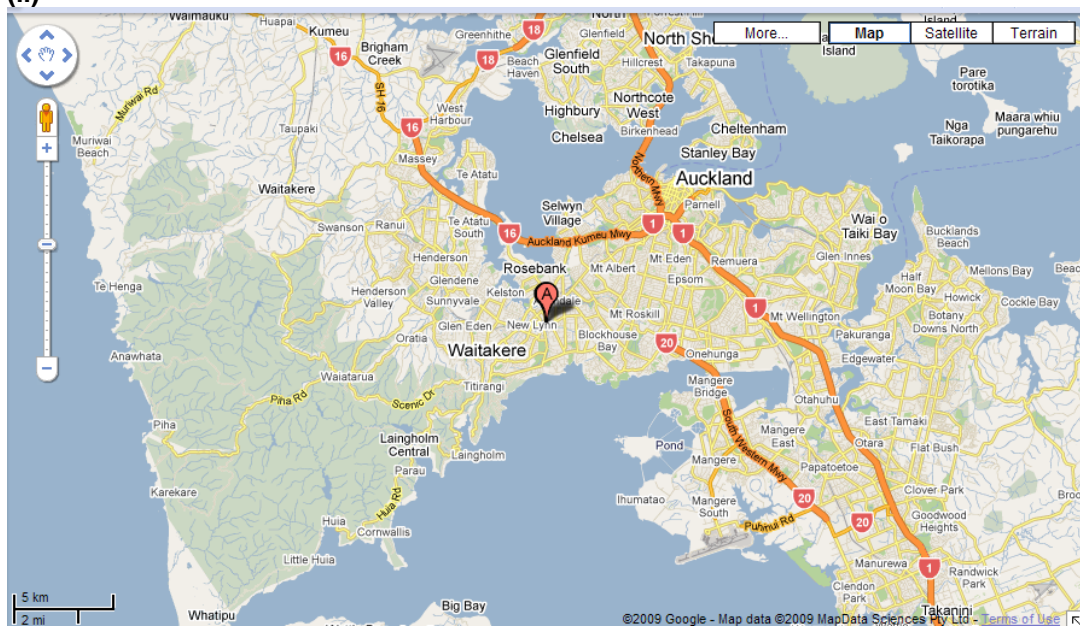


Figure 6: Map of Olympic Park, New Lynn, Auckland, North Island, New Zealand (i) and maps (ii, iii) showing its location (A) in New Zealand (from Google Maps)

(i)



(ii)



(iii)

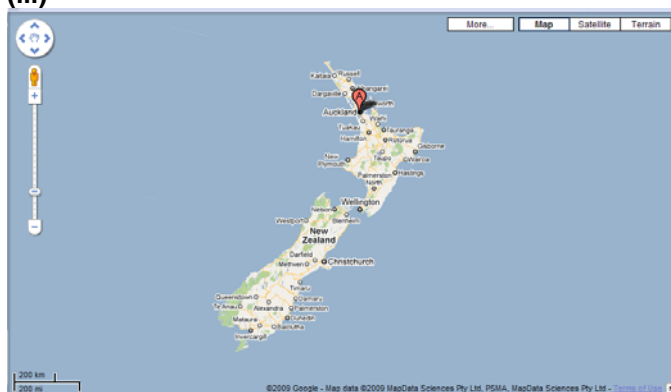


Table 2: Established Ecological Concepts that are Generally Understood by Restoration Practitioners (from Young et al. 2005)

Ecological concept	Relevance to restoration
Competition	Plant species compete for resources, and competition increases with decreasing distance between individuals and with decreasing resource abundance.
Niches	Species have physiological and biological limits that restrict where they can thrive. Species selection and reference communities need to match local conditions.
Succession	In many ecosystems, communities tend to recover naturally from natural and anthropogenic disturbances following the removal of these disturbances. Restoration often consists of assisting or accelerating this process. In some instances, restoration may need to repair underlying damage (soils) before secondary succession can begin.
Recruitment limitation	The limiting stage for the establishment of individuals of many species is often early in life, and assistance at this stage (such as irrigation or protection from competitors or herbivores) can greatly increase the success of planted individuals.
Facilitation	The presence of some plant species (guilds) enhances natural regeneration. These include N-fixers and overstorey plants, including shade plantings and brush piles.
Mutualisms	Mycorrhizae, seed dispersers and pollinators are understood to have useful and even critical roles in plant regeneration.
Herbivore/predation	Seed predators and herbivores often limit regeneration of natural and planted populations.
Disturbance	Disturbance at a variety of spatial and temporal scales is a natural, and even essential component of many communities. The restoration of disturbance regimes may be critical.
Island biogeography	Larger and more connected reserves maintain more species, and facilitate colonization, including invasions.
Ecosystem function	Nutrient and energy fluxes are essential components of ecosystem function and stability at a range of spatial and temporal scales.
Ecotypes	Populations are adapted to local conditions, at a variety of spatial and temporal scales. Matching ecotypes to local conditions increases restoration success.
Genetic diversity	All else being equal, populations with more genetic diversity should have greater evolutionary potential and long-term prospects than genetically depauperate populations.

2.3 Results

2.3.1 Has ecology been incorporated into ecological restoration guidance?

The following section presents the results of assessing the inclusion and use of ecological theory in the planning, implementation and evaluation sections of available ecological restoration guidance.

Planning

Between all of the guidebooks assessed in this study there is variability in the level of attention given to the planning phases of ecological restoration – some providing specific goals and objectives to be considered, while others (e.g. Porteous 1993; Davis & Meurk 2001) put more effort into presenting the techniques for implementing restoration. Atkinson (1994) and Clewell et al. (2000) include some objectives relating to social/cultural/economic dimensions of restoration, while the objectives identified in Harker et al. (1999) and Porteous' (1993) guidebooks are entirely focused on ecological outcomes. Clewell et al. (2000) specify that goals relating to social/cultural values may be prescribed as long as they are congruent with the primary goal of restoring a functional ecosystem. Davis & Meurk (2001) identify ecological/social/legal reasons for restoration but do not set out any specific guidelines on how to set goals and objectives under these motivations. Some examples of goals are very briefly provided (Davis & Meurk 2001, p.15, 37) but they are focused on reinstating ecological structure and are extremely vague. Perrow & Davy's (2002) *Handbook of Ecological Restoration Vol. 2* provides no specific guidance on planning or setting objectives in a restoration strategy and this may relate to the overall style of the handbook, which appears to be designed for experienced practitioners that have a sufficient level of ecological knowledge.

Where ecological goals and objectives have been clearly specified, all focus on delivering both structural and functional endpoints. Harker et al.'s (1999) handbook is specifically designed for practitioners restoring ecosystems in the United States and therefore, while Chapter 6 provides some general guidance for planning and implementing restoration, it is very much geared towards the circumstances presented in the United States.

A number (8/12 – 12/12) of Young et al.'s 12 concepts (2005) are incorporated into the planning sections of the guidebooks assessed (Atkinson 1994; Clewell et al. 2000; Harker et al. 1999, and; Perrow & Davy 2002). Davis & Meurk's (2001) guidebook, which focuses more on presenting specific implementation techniques, fails to identify any of Young et al.'s 12 concepts in the planning framework.

Implementation

Of all the guidebooks assessed, only Davis & Meurk (2001), Harker et al. (1999) and Porteous (1993) provide information regarding techniques and methods for implementing restoration. Harker et al. (1999) focus on the importance of species selection appropriate to region, while Davis & Meurk (2001)

and Porteous (1993) present in great detail the diversity of techniques available for addressing different aspects of restoration such as planting, pest and weed removal, fencing etc. Perrow & Davy do not present any specific methods for implementing restoration, however, they do discuss some of the important factors that require consideration when restoring different ecosystem types. Atkinson (1994) and Clewell et al. (2000) do not describe any particular methods for implementing restoration although Clewell et al. (2000) state that this is beyond the scope of their guidebook.

In the three guidebooks that explicitly present methods for implementing restoration (Davis & Meurk 2001; Harker et al. 1999, and; Porteous 1993), all focus on methods for meeting both structural and functional ecological objectives, although Davis & Meurk (2001) have a greater focus on implementation for ecological structure. In addition, all of the methods identified in the three guidebooks encompass the 12 ecological concepts presented by Young et al. (2005). None of the guidebooks however, provide any methods for achieving social/cultural/economic objectives in restoration.

Evaluation

All of the guidebooks recommend some form of evaluation for monitoring and assessing restoration progress. Atkinson (1994), Clewell et al. (2000) and Perrow & Davy (2002) emphasise evaluating the achievement of both ecological and social restoration objectives, while Davis & Meurk (2001), Harker et al. (1999) and Porteous (1993) recommend evaluating ecological objectives alone.

Within the ecological evaluation described in guidebooks, all except Davis & Meurk (2001) prescribe assessing both structural and functional progress of the project. Davis & Meurk (2001) focus on monitoring ecological structure alone e.g. plant species presence, density, abundance, animal pest numbers etc. Few of the guidebooks actually present specific methods for evaluating restoration progress. Clewell et al. (2000) indicate that this is contingent on planning objectives. Harker et al. (1999) and Porteous (1993) both recommend that monitoring and evaluation is important but neither provides advice or techniques for doing so.

Atkinson's (1994) section on evaluation is the only one that incorporates any of Young et al.'s (2005) ecological concepts. Atkinson (1994) specifies that while it is important for monitoring methods to be standardised with individual restoration projects, it may be premature to prescribe a standard set of evaluation techniques across all restoration projects, given that restoration ecology is still relatively experimental.

2.3.2 Has ecology been incorporated into New Zealand restoration project plans?

The following section presents the results of assessing the inclusion and use of ecological theory in the planning, implementation and evaluation sections of selected New Zealand restoration project plans.

Planning

Ecology is a primary focus of the goals and objectives of all restoration management plans.

The extent to which plans are balanced with social/cultural/economic goals is variable, and largely depends on the motivations for undertaking the restoration. The Lake Wairarapa Wetlands restoration plan (DoC 2000) is prompted by the Department of Conservation's (DoC's) Conservation Management Strategy for Wellington and specifies one ecological objective and four social/cultural/economic objectives. The Korapuki Island restoration plan (DoC 2004) does not list any social/cultural/economic objectives and this is because Korapuki Island has a reserve status that limits public access. Tiromoana Bush restoration plan (Transwaste Canterbury 2005) has been established as a part of landfill resource consent and therefore, five out of six restoration goals are ecological and the planning framework sets out 300-year, 35-year, 5-year and 1-year vision/targets. Olympic Park, a small public urban reserve, lists six ecological and six social/cultural/economic objectives in its restoration plan (Brakey & Weaver 2001). Similarly, Caversham Valley forest reserve located in the urban outskirts of Dunedin also emphasises social/cultural/economic goals within the plan, where only one out of four goals are ecological (Dunedin City Council 1996). The Maungatautari Restoration Plan (McQueen 2004), which largely involves the fencing of a large (3,200ha) area of land to create an 'ecological island' in the central North Island, only presents the ecological goals associated with restoration framework however, it is indicated that a separate plan for education and recreation exists (although it does not appear to be available).

Five of the six plans include ecological objectives that pertain to both structural and functional success; Caversham Valley restoration plan does not consider ecosystem function within planning criteria.

The incorporation of Young et al.'s (2005) 12 ecological concepts within the planning frameworks of ecological restoration plans is difficult to distinguish. In most cases, these ecological concepts are not explicitly identified and rather, implicitly or indirectly woven into context of the plan via e.g. background information, or description of the ecological context/features of the site; Lake Wairarapa, Tiromoana Bush, and Maungatautari restoration plans are demonstrative of this, where 10-11 of Young et al.'s (2005) concepts could be identified. The planning framework for Korapuki Island is an excellent example of how ecological concepts can be incorporated within the planning context, providing conceptual trophic models to illustrate the historical and future (restored) ecosystems. Less than seven ecological concepts could be identified in the restoration plans for Olympic Park and Caversham Valley.

Implementation

The methods for implementing ecological objectives are unique to each plan. However generally, the incorporation of ecology within implementation sections of restoration plans reflects the extent to

which ecology is balanced against other objectives included within the project planning. For example, in DoC's Lake Wairarapa restoration plan, where four out of the five planning goals are social/cultural/economic, four out of five methods for implementation focus on social/cultural/economic actions. DoC even specifies within the plan that they will not implement ecological aspects of restoration unless there are threatened plants or animals at stake – instead they promote that the community take responsibility to action ecological restoration techniques and research, again enhancing the overall social/cultural/economic objectives of the project as an educational exercise. Caversham Valley restoration plan sets out management 'policies' rather than 'actions' or 'techniques', making it difficult to distinguish whether they are meant for guiding planning or implementation, although this could be more reflective of the language used by its publisher (Dunedin City Council). Tiromoana Bush restoration plan provides excellent detail regarding methods for implementing ecological goals over 1-300 year timeframes. The plan also sets out the abiotic/biotic constraints of restoration and identifies appropriate responses. This may be a requirement of the resource consent associated with this restoration plan.

Olympic Park is a very small management plan (only 3 pages). The plan presents a planting schedule for implementing one ecological objective i.e. successful planting. Outside of this, a series of 'features' describes the desired endpoints of implementation, rather than the process for achieving these 'features'.

Korapuki Island provides a conceptual trophic model for implementation through to 2024 and draws upon Middle Island as a reference ecosystem. While the implementation strategy sets out to 'recreate biological communities that previously existed', it recognises that this should only be a guide, since current conditions may mean that the island succeeds towards a unique community.

Although implementation of ecological restoration within all of the plans is directed towards structural and functional success, ecological concepts are difficult to identify explicitly (sensu Young et al. 2005). The concepts that are most explicit within implementation sections include eco-sourcing, succession, niches, herbivory/predation, island biogeography, and recruitment limitation. Few management plans identify ecological concepts using Young et al.'s terminology. Rather, ecological concepts are generally exemplified in management plans through their relevance or conceptual meaning. For example, restoration plans may present methods for ensuring ecological connectivity of the site to the surrounding landscape, rather than present this in terms of "island biogeography".

Evaluation

Few of the ecological restoration plans present specific methods for evaluating project success, or who will be responsible for monitoring/evaluation. Further, all of the restoration plans that specified social/cultural/economic goals failed to include any means for evaluating their achievement; Lake Wairarapa, Tiromoana Bush and Caversham Valley were among this group. Maungatautari restoration plan sets out clear methods for monitoring ecological progress, while the restoration plan for Olympic Park provides no reference to evaluation or monitoring. Korapuki Island restoration plan indicates that there is another (separate) document describing methods for measuring the success of

the project (unavailable). Similarly, Tiromoana Bush restoration plan provides a general indication of standard ecological monitoring methods to be used but indicates that further detail is included in annual restoration plans for the site (unavailable).

2.4 Discussion: Inclusion of ecology in restoration guidance and project plans

The ecological restoration guidelines assessed in this study show no consistency or standardisation in methods for planning, implementing and evaluating restoration projects. There is inconsistency in the extent to which ecology as an objective is balanced against other (social/cultural/economic) objectives. Some guides provide specific practical methods/techniques that focus on the process of implementing restoration, while others do not progress further than the conceptual stage, focusing on presenting the desired endpoints and outcomes rather than the specific means for getting there. Evaluation techniques tend to be poorly expressed and few link back to the objectives or conceptual purpose of the ecological restoration. None of the guidelines present methods for evaluating the social/cultural/economic objectives of restoration.

The lack of a standard set of guidelines for practitioners may reflect the diversity of approaches, methods, language and structure of ecological restoration plans assessed in this study. This is consistent with MacMahon & Jordan (1994) and Cairns (1998), who suggest that because there are no standard methods available in restoration ecology, very little of ecological restoration practice is routine. It is noteworthy however, that none of the ecological restoration plans evaluated make reference to any of the guidebooks assessed in this study. This may indicate that practitioners do not tend to utilise guidebooks in developing ecological restoration plans, which is conceivable, as the assessed restoration guidebooks do not adequately cater for the social/cultural/economic objectives that predominate in the ecological restoration plans.

The authors and their motivations may also influence the format, structure and language of ecological restoration plans. While plans written by local authorities and the Department of Conservation (DoC) reflect the legal/statutory framework associated with the ecological purpose of restoration, the social/cultural values of restoration are a key focus in plans written by community groups/Trusts. In addition, DoC has a legal responsibility to 'protect and enhance' rare and endangered biodiversity, therefore, restoration plans authored by DoC are directed towards this purpose and tend to align with the language used in the New Zealand Resource Management Act 1991 (RMA). By contrast, community projects are written for community practitioners, and use simple practical language to incorporate a diversity of ecological/social/cultural/economic values of restoration. As a consequence, DoC inevitably ends up championing the restoration of large, remote sites as a priority, leaving the restoration of smaller, (perceived lower priority) urban sites for community groups to implement.

Therefore, the spatial scale and conservation value of a site affect the ownership of responsibility for its restoration.

Perhaps what is most notable about the inclusion of ecological concepts in restoration guidance and plans is *how* they have been included. Restoration guidance (theory) often describes concepts directly using the appropriate ecological terminologies as presented by Young et al. (2005), while restoration plans (practice) tend to incorporate ecological concepts indirectly, exemplifying them in the context of their conceptual meaning or relevance to restoration. Ecological restoration plans steer away from describing practice in terms of ecological terminology such as competition, niches, island biogeography, and recruitment limitation.

This difference in language further highlights a disconnection between ecological restoration theory and practice. As outlined previously, not only are ecological restoration guides inadequately accommodating the social/cultural/economic objectives of restoration practice, but this study has also identified that the way in which ecology is understood in restoration theory is different to the way in which it is interpreted in practice. These findings provide definitive implications for progressing the incorporation of ecological theory in restoration guidance and plans; restoration guidance needs to incorporate ecological theory within the social/cultural/economic framework that represents restoration practice on the ground.

Learning from other research

The problems identified above are not new. In their investigation of stream corridor restoration, Shields et al. (2003) state that as a function of the loose definition of restoration terms and the long response times of stream corridor restoration, restoration experiments are poorly controlled or are uncontrolled and have outcomes that are not reproducible. They also state that social and economic issues impede restoration progress, such as uncooperative landowners causing ecological objectives to be compromised and the difficulty in quantifying the economic benefits of ecosystem services provided by restoration.

Saunders and Norton (2001) follow a similar line of thought to Bradshaw (1987) and suggest that advances in our understanding of ecological theory appropriate to mainland island restoration (*areas of the mainland that are isolated by fencing, geographical features or, more commonly, intensive management of pests*) will result from using sound scientific procedures as a part of management programmes to test theory and refine management techniques.

In order to test ecological theory within the context of restoration, rigorous techniques for evaluating the success of various trials are critical. A variety of methods have been identified in the literature. Grayson et al. (1999) emphasise the necessity of developing clear and realistic restoration goals that facilitate the formulation of predictive hypotheses and appropriate sampling design in the evaluation of restored urban wetlands.

Kentula (2000) distinguishes three different kinds of broad ecological success criteria for wetland restoration, including: 'compliance success' – how well the project meets the ecological terms of an agreement; 'functional success' – how well the ecological functions of the system have been restored, and; 'landscape success' – the extent to which the restoration has contributed to the ecological integrity of the surrounding region or landscape.

Anand and Desrochers (2004) propose that because ecological restoration trajectories may be complex, the quantification of restoration success requires the use of well-known complex systems theory and models. Lirman and Miller (2003) suggest that a combination of monitoring and simulation modelling applied to the restoration of coral reefs will effectively provide the necessary tools to assess the current status of a restoration effort and to project the time required for coral populations to resemble those found on undamaged reference habitats. Block et al. (2001) identify a simpler framework for evaluating the success of restoration on wildlife involving the selection and monitoring of umbrella species that represent a range of spatial and functional requirements of wildlife in a restored ecosystem. However, they emphasise the importance of scientific rigour in the design and implementation of this monitoring framework.

The diversity of methods proposed for evaluating the ecological success of various types of restoration suggests that there is no one-off solution for understanding how to test ecological theory in restoration practice. It may not even be appropriate to categorise the 'success' of a restoration project based on ecological values alone. Ehrenfield (2000) postulates that as a function of the social values associated with restoring wetlands in urban areas, evaluating their perceived 'success' should be different to assessment of wetland restoration success in non-urban areas.

Since restoration embodies both social and ecological dimensions, Glacken's (1976) approach provides another perspective in considering the application of ecology in the restoration context. Glacken's key questions are relevant: Does the earth shape human life and how have humans affected the earth? Was the purpose of nature to create some benefit for humans, as Aristotle wrote? While this more anthropogenic perspective may not be theoretically correct, it is perhaps an important mechanism for marketing restoration to the groups that need to be engaged – humans. For example, Miyawaki (1998) asks an important question: should restoration best be promoted in the context of preserving human life? He describes 600 forest sites that have successfully been restored using the concept of 'green infrastructure' as a framework for promoting restoration to the public. Coen and Luckenbach (2000) suggest that initiatives associated with the restoration of e.g. oyster habitat are directly motivated by a need to maintain oysters as a commercially exploitable resource for humans.

Similarly, Cairns (2000) indicates that human society needs to approve the goals and objectives of restoration in order for it to successfully progress. This means that ecological restoration needs to be linked to concepts such as sustainable land-use to foster society's interest. Hackney (2000) resonates these ideas and further proposes society will continue to support restoration if it is a part of the decision-making process. This implies that restoration management plans need to have clear

objectives and goals that the public understand and that benefit the public at large (Hackney 2000) and that the process requires regulatory recognition.

Kendle & Rose (2000) raise an important point around sustainability, proposing that as humans need to initially *be perceived* as a part of the 'natural world' in order to foster a positive influence and a place in a 'sustainable world'. Therefore, in the context of forming guidance and plans appropriate for restoration ecology, it may be appropriate to first consider developing an inclusive framework that views the social dynamics of restoration - the roles that people have in the restoration process - as inherent or component parts of the 'ecological' process of restoration.

These ideas will be explored further in Chapters 4 - 6.

2.5 Conclusions

This study set out to investigate whether/how ecological theory has been incorporated into: (1) current ecological restoration guidance available to New Zealand practitioners and; (2) ecological restoration plans developed by New Zealand restoration practitioners.

The following conclusions can be drawn:

- There is variability in the extent to which ecological theory is incorporated into ecological restoration guidance. As a consequence, there are no standardised methods for planning, implementing or evaluating ecological restoration among the guidebooks assessed in this study.
- The ecological restoration guidebooks evaluated in this study fail to adequately incorporate the social/cultural/economic dynamics of ecological restoration.
- There are inconsistencies in the goals, methods, structure and language of ecological restoration plans assessed in this study. This may be due to:
 - The diversity of guidance available for assisting the development of plans.
 - The skills & values of authors responsible for creating & implementing restoration plans.
 - The different motivations for undertaking the restoration.
- Restoration guidance (theory) describes ecological concepts directly using the appropriate ecological terminologies as presented by Young et al. (2005), while restoration plans (practice) tend to incorporate ecological concepts indirectly, exemplifying them in the context of their conceptual meaning or relevance to restoration. Therefore, restoration guidance may be improved by selecting to discuss ecological concepts in terms of their meaning or relevance to restoration, rather than by using academic terminologies.
- Restoration guidance may be further improved by incorporating the social/cultural/economic dynamics of ecological restoration in an inclusive 'ecological' framework that recognises people as a part of the 'natural' process of ecosystem development and the sustainability of the planet.

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Chapter 3

Can ecology provide more for ecological restoration?

3.1 Introduction

The previous chapter identified wide variability in the application of ecological theory in restoration guidebooks and restoration project plans. Ecological theory has been open to subjective interpretation in the restoration context, leading to inconsistency in approach and inconclusive restoration results.

Given it is the ecology of a place that is being managed through restoration, a clear and coherent understanding of the subject is required as a foundation for progressing research in restoration ecology.

The information that is available on the subject of ecology is a collective of theory spanning more than a century composed of conceptual and applied experiments, models, hypotheses, laws, rules, ideas, terminologies, definitions, techniques and methods. In many instances, there are several types of explanation for the same ecological phenomena (e.g. succession theory, biodiversity, biogeography), often accompanied by supporting evidence, making it difficult to decipher if one is more correct than the other. Coupled with multiple definitions for ecological terminologies and the use of non-standardised methods for data collection and analysis, ecological theory comprises very confusing and messy databases of reference information.

The first part of this chapter attempts to extrapolate the ecological theory relevant to restoration ecology by exploring the fundamental issues in developing ecological theory and by investigating the core theories that have practical relevance to the pattern and process of development embodied in restoration.

The second part of the chapter focuses on identifying an ecological model suitable for ecological restoration. An ecological reference model for restoration needs to quantitatively describe the changes that occur as an ecosystem develops and provide indicators that can be monitored to measure ecosystem change. The rationale for applying E. P. Odum's (1969) model of *Trends to be Expected in the Development of Ecosystems* in the restoration context is presented.

3.2 Fundamental issues with existing ecological theory

Current conceptual restoration approaches have evolved largely from ecological theory and studies in applied ecology. Ecological theory often incorporated into conceptual restoration models includes: ecological succession and disturbance; landscape ecology; community assembly rules; trophic interactions; population dynamics; species ecology, and soil ecology. Unfortunately, unlike the 'hard' sciences of physics and chemistry, few theories in ecology are consensually established (Sagoff 1988; Peters 1991; Botkin 2000). This is perhaps because ecology ranges over many diverse areas including marine, freshwater, and terrestrial and involves all taxonomic groups, from bacteria and protozoa to mammals and forest trees, at all levels - individuals, populations, and ecosystems. Any of these levels and groups may be studied from various points of view, e.g. behavioural, physiological, and chemical. As a result ecology, by necessity, involves isolated groups of specialists (McIntosh 1982; Smith 1996) and is a science consisting mainly of hypotheses, models, case studies, and "rules-of-thumb" (Shrader-Frechette & McCoy 1993, 1994; Shrader-Frechette 1995).

Unfortunately this has meant ecology as a discipline is scarred by variability, including: a diversity of terminologies to explain the same phenomena, e.g. 'food web' versus 'interaction web' terminologies (Price 2002); a range of definitions for the same terminology e.g. 'disturbance' definitions (White & Jentsch 2001); a variety of models that describe the same process e.g. succession models (Odum 1969; Connell & Slayter 1977; Grime 1979; Noble & Slayter 1980; Tilman 1985); and numerous different field techniques that provide varying results for the same line of enquiry (Korb et al. 2003). In other cases, the application of ecological theory to the restoration context is limited by the parameters selected to create the theory. For example, the use of historical ecosystem reference data in restoration is limited by the unmeasured factors that confound the interpretation of the historical changes observed (White & Walker 1997).

Therefore, Bradshaw's (1987) notion of using ecological restoration as an acid test of our understanding of ecology is made more difficult by the fact that our understanding of ecology is inconsistent at the outset. The embedded issues in ecology become exacerbated when applied to the restoration context, creating uncertainty as to how results scale up to landscape and regional levels and generalise across ecosystem types and processes (Loreau et al. 2001). Indeed, many of the issues in restoration ecology are themselves central to much of the basic research in ecology (Ehrenfeld & Toth 1997). For example, the role of individual species in ecosystem dynamics is a key issue in ecological research, as massive changes in biodiversity and species distributions coincide with equally massive changes in global cycles of key elements (Schulze & Mooney 1994; Vitousek 1994; Jones & Lawton 1995); much of this research is also relevant to restoration ecology.

Some have made attempts to overcome these issues and bring greater organisation and coherency to ecological theory through the process of synthesis (Turchin 1999; Pickett 1999). Ford & Ishii (2001)

note that synthesis may be the key to developing integrative concepts that can be communicated to a general audience.

3.3 Making sense of ecological theory

Given the issues above, making sense of ecological theory is a difficult process. However, it is possible that restoration ecology provides an opportunity to clarify some of the anomalies that exist. It is therefore useful to focus on specific ecological theory that could be more fully explored in the restoration context. This section defines the core ecological theories that have a specific relevance to undertaking the pattern of development embodied in restoration. These include: succession and community development; diversity, stability and function; seed limitation, and; soil microbial communities. An appreciation of the literature is presented as a foundation for understanding the relevance of these ecological theories in the restoration context.

Succession and community development

The last century has seen a large number of approaches to explain ecosystem succession. Arguably, the most controversial aspect of the subject has circled around the climax concept of succession.

Clements (1916) postulated a theoretical framework for the idea of a mono-climax; that successional sequences were climatically determined, leading to a single, self-perpetuating climax community. This idea, known as the organismic concept, has become embodied in ecological literature, despite challenges from the alternative hypotheses of more recent theorists.

These include Gleason (1917; 1926), who criticised Clements' mono-climax theory because it lacked accommodation of individual plant population behaviours, as well as Tansley (1935), who proposed the poly-climax theory. Here, Tansley postulated that a climax community exists, but consists of a mosaic controlled by local soil moisture, nutrients, parent material, topography, slope exposure, fire, and animal activity.

Whittaker (1953) proposed the climax-pattern hypothesis as a modification of the poly-climax viewpoint. The climax-pattern hypothesis combines community and environmental gradients to yield a variety of climax stands in an area that forms part of a continuous mosaic. Succession proceeds toward one of an infinite number of alternative climax communities, each in equilibrium with its own unique site as a function of the success of populations of species in relation to local environmental gradients.

Over time, ecologists have sought a mechanistic rather than pathway-oriented understanding of succession (Pickett et al. 1987). Various models have been proposed, such as population-based approaches (Peet & Christensen 1980; Finegan 1984), e.g. the Vital Attributes model (Noble & Slayer 1980); the facilitation, inhibition and tolerance models (Connell & Slayer 1977); Grimes C-S-R hypothesis (1979); and Tilman's (1985) resource-ratio hypothesis. Other mechanistic explanations of succession include Egler's (1954) relay floristics and initial floristic composition concept, Horn's (1974)

Markovian models and Huston and Smith's (1987) non-equilibrium model. More recent perspectives contend that the successional climax is an 'ideal' and an abstraction of reality (Pickett & McDonnell 1989).

There is a lack of general agreement among ecologists regarding which of the above successional principles are established or accepted (McIntosh 1980, 1985; Shugart 1984). Consequently, there can be dissension among scientists about the degree to which sites are self-regulating and whether there are endpoints to succession (Pickett & Parker 1994; Aronson et al. 1995).

The fact that there is no universal agreement upon the endpoint of succession, i.e. a deterministic climax, is perhaps not important. Part of the problem in finding general agreement in ecological concepts like succession may actually be one of scale (Loucks 1970; Marks & Borrmann 1972; Whittaker & Levin 1977; Allen and Hoekstra 1992). That is to say, the scale of the specific endpoints selected will determine the evaluation of restoration success. For example, measuring the presence/absence of a species provides a different unit of resolution to absolute abundances, and this may constrain the assessment of project success (Palmer et al. 1997).

Therefore, one of the keys to enable the concept of succession to be applied to the restoration context is assessing and understanding the spatial and temporal scale at which mechanisms that drive and control succession are expected to operate (McIntosh 1980, 1985; Allen & Starr 1982; Shugart 1984; O'Neill et al. 1986; Carlile et al. 1989; Hoekstra et al. 1991; Brand & Parker 1995).

Successional theory and state-transition models have been a conceptual basis for restoration since its beginning. State-transition community models are similar to succession models in assuming a restricted set of community states and a set of limits to transitions between those states (Allen-Diaz & Bartolome 1998; Bestelmeyer et al. 2004).

The recent development of assembly theory and relevance of alternative stable states to today's 'natural' world has stimulated a number of books and articles (Packard 1994; Lockwood 1997; Palmer et al. 1997; Weiher & Keddy 1999; Walker & del Moral 2003; Temperton et al. 2004). Restoration ecology can be placed in the established domain of succession theory by viewing restoration as initiating and/or accelerating the assembly of a collection of species into a community. Assembly theory, in discovering sets of rules that govern the assembly of ecosystems and communities, possesses the capacity to delineate what management strategies will be effective under different circumstances in directing succession toward a desirable state. For example, assembly theory may help a restoration practitioner to refine methods for managing the succession of a New Zealand Podocarp/broadleaf forest on an island versus those suitable for managing a New Zealand Podocarp/broadleaf succession on the mainland due to the different circumstances presented in the two environments.

Assembly theory is consistent with the dynamic (or non-equilibrium) paradigm of succession theory (i.e. Gleason). Any apparent stability is localised and temporary, although timescales may outlive generations of humanity. Complexity characterises dynamic systems with ecosystems featuring a number of behaviours: alternative stable states; multiple trajectories for community assembly that are dependent on the timing of a host of historical contingencies including disturbance; non-linearities such as threshold events; patchiness in pattern and process; and fluxes in species and resource availability across the landscape. A significant gap exists, however, in the extent to which assembly theory can inform decision making in restoration projects, primarily because assembly models and theory have not yet been tailored to the restoration endeavour. Using the example in the previous section, although assembly theory may help the practitioner to understand the range of ecological trajectories/scenarios for achieving a Podocarp/broadleaf forest, humans are a unique part of the successional process in restoration and therefore, assembly models appropriate for restoration need to incorporate this important circumstance.

Assembly theorists are now investigating additional forces that can move community trajectories in different directions beyond colonization and priority effects (Temperton et al. 2004; Tilman 2004). Indeed, the role of disturbance in assembly theory is still highly debated (Temperton et al. 2004). Evidence in practice suggests that disturbance has multiple roles and mechanisms by which it drives the trajectory of community assembly. For example, fire affects nutrient availability by creating ash beds and a release from competition (Sadler 2005). A heterogeneous pattern of fire across a landscape can promote species diversity by leaving a wake of communities at different stages of assembly. Contrast this with fire intensity, which acts as a filter by constraining the potential list of species to those able to withstand severe fires. This example merely illustrates that there is still yet much to be learned in the realm of disturbance and assembly and in the application of that knowledge to restoration. Further, as the conceptual frameworks of succession and assembly can have very different predictions these also need to be tested in restoration settings (Wilson et al. 2000).

Diversity, stability and function

Of all of the areas in ecology, the study of species diversity has one of the longest histories and most substantial volumes of literature (Palmer et al. 1997). One of the major challenges for restoration ecologists is determining the minimum number of species necessary for proper community function: Can community or ecosystem stability be increased by adding more species (enhancing diversity) or particular species in the restoration process? May (1973) presented mathematical evidence that diverse systems are less stable than simpler ones. The idea was that the more diverse a community, the more complex the web of species interactions, and thus the larger the effect that disturbances would have on the system. Subsequent research (Naeem et al. 1994; Tilman et al. 1994; Tilman 1996) has revealed that while diversity may make individual species more vulnerable to extinction, total community or ecosystem properties (e.g. energy transformation, biomass) may be stabilized, since some species compensate functionality for others. This has led to more detailed investigation about the relationships between species diversity and a variety of ecosystem functions, such as the

relationship between biodiversity and plant litter (Wardle et al 1997); the affect of resource availability on plant species diversity and ecosystem function (Fridley 2002); and the affect of mycorrhizae on diversity and function (Klironomos et al. 2000) amongst many studies in this area (Waide et al. 1999; Schwartz et al. 2000; Tilman et al. 2001; Cardinale et al. 2004; Hooper et al. 2005). What mechanisms drive these relationships? How many species are sufficient for a particular function? These questions are of central interest to restoration, and restoration experiments may provide an ideal setting for testing them. Diversity studies have suggested that full ecosystem function can be achieved with 10-15 species (Fargione et al. 2003) or even fewer (Wardle 2002; Tracy & Sanderson 2004), and that the presence of different functional groups is often an important driver of ecosystem function (Hooper & Vitousek 1998). For example, Fargione et al.'s (2003) species-addition experiment showed that prairie grasslands have a structured, non-neutral assembly process in which resident species inhibit, via resource consumption, the establishment and growth of species with similar resource use patterns and in which the success of invaders decreases as diversity increases. Both these results have clear implications for restoration, but as yet have rarely been the subject of formal study in restoration settings.

In terms of long-term stability and function, it is useful to keep in mind that given sufficient time, almost any degraded or destroyed ecosystem will restore itself (Bradshaw 1987). This underscores the importance of 'acting now' with restoration effort; practitioners should be less concerned about 'getting it right' and focus on the purist purpose of restoration, which is speeding up ecosystem recovery through active assistance.

Seed limitation

Restoration techniques often include re-establishing vegetation cover on a particular site as a way of manipulating or accelerating vegetation change (Whisenant 1999; Palmer et al. 1997). This can often be a resource-intensive exercise where sites in fragmented landscapes are missing seed banks, thereby limiting the capacity for the establishment of diverse species assemblages and potential for dispersal (Stampli & Zeiter 1999; Seabloom & van der Valk 2003). Several studies recently have focused on investigating seed limitation as a factor governing plant community structure and mechanisms of species coexistence (e.g. Turnbull et al. 1999; Pywell et al. 2002; Seabloom et al. 2002; Foster & Tilman 2003). Turnbull et al.'s (1999) sowing experiment in limestone grassland, South Wales, suggests that seedlings do compete for establishment sites and that large-seeded species generally win when in direct competition. Seabloom & van der Valk's (2003) study of wetlands in the mid-west USA found that dispersal limitation is the primary cause of the differences between the vegetation in restored and natural wetlands.

From the ecology literature, it is not clear to what extent lack of seeds limits recruitment in natural plant populations, and its importance relative to other factors (Crawley 1990). However, sowing additional seeds on even undisturbed sites frequently does increase the number of established individuals of seeded species, indicating that there are more safe sites than seeds to fill them for some

species in many communities (e.g. Tilman 1997; Turnbull et al. 2000; Zobel et al. 2000; Foster & Tilman 2003). These results suggest that likelihood of seed arrival does influence community structure in some communities, (McEuen & Curran 2004).

Several examples from New Zealand illustrate the importance of considering seed limitation in restoration. In New Zealand, the impacts of exotic species such as deer can be irreversible, reducing the local seed pool and subsequently, altering fundamental successional pathways and the trophic dynamic between plants and animals (Coombes et al. 2003). About 70% of the woody plants in New Zealand forests have fruits suited for vertebrate dispersal and, of these, most are dispersed by birds (Clout & Hay 1989). It therefore follows that these bird populations are limited by food supply (Armstrong et al. 2002). Mast seeding years are another phenomena of New Zealand podocarps. As these podocarps are a food supply for the rare endemic bird *Strigops habroptilus* (kakapo), studies have shown that irregular mast fruiting years may regulate the population of rare endemic kakapo by temporarily supporting increased rat (*Rattus exulans*, *R. rattus*, *R. norvegicus*) densities, and as a consequence cat (a predator of the kakapo) densities increase. This is similar to the phenomena of irregular beech (*Nothofagus* spp.) mast-seeding in Fiordland promoting house mouse (*Mustela musculus*) population eruptions, which in turn lead to increased stoat (*Mustela erminea*) densities (Fitzgerald 1978; King 1983). These examples illustrate the potential magnification of the consequential effects of seed limitation on entire ecosystems and thus, the relevance of seed limitation in restoration decision-making.

Soil microbial communities

Soil microbes play a fundamental role in facilitating the success of higher plants and for overall ecosystem health. Plants with nitrogen-fixing symbioses have been used throughout the history of restoration (e.g. Requena et al. 2001). Mycorrhizal associations have also been long explored in restoration settings, where their benefits have been repeatedly demonstrated (Smith & Read 1997), although the necessity of active mycorrhizal introduction is less clear (Renker et al. 2004).

Few studies have captured the feedback relationships that exist between soil microbes and the wider ecosystem. Ingham et al.'s (1986) study of semi-arid grasslands illustrates that perturbations, such as grazing, can affect the balance of below-ground trophic food web relationships and subsequently, the system nitrogen cycling. For example, increased grazing subsequently caused a reduction in microbial biomass and decomposers, and increased grazer numbers occurred concomitant with increases in soil inorganic nitrogen.

Other species in the system may also serve to facilitate the establishment of soil microbes - Anderson and Sparling's (1997) studies on restoring mine sites show a positive correlation between above-ground ant activity and belowground decomposition processes, suggesting that ants could be useful indicators of restoring below-ground microbial activity in mine sites. Bardgett and Wardle (2002) propose a variety of possible mechanisms responsible for the idiosyncratic nature of herbivore effects

on soil biota and ecosystem function; positive, negative, or neutral effects of herbivory are possible depending upon the balance of these different mechanisms.

Some soil organisms have the ability to reduce available soil nitrogen, especially when provided with excess carbon (Torok et al. 2000). In sites degraded by high levels of nitrogen, restoration practitioners have explored various forms of carbon addition to reduce soil nitrogen. These techniques can work in the short run, but often have limited long-term effects (Blumenthal et al. 2003; Baer et al. 2004). Curiously, such studies have rarely directly measured microbial responses to carbon addition (Corbin & D'Antonio 2004), but instead their inferred effects on soil nutrient conditions. Manipulations of soil microbial communities may also facilitate restoration of sites with high levels of salts or toxic metals (Kernaghan et al. 2002). The importance of soil aggregates, and their reliance on soil microbes, has also recently caught the attention of restoration ecologists (Jastrow et al. 1998; Requena et al. 2001; Rillig et al. 2003), where soil aggregates may play a key role in stabilizing and progressing restoration.

3.4 Identifying an ecological model for ecological restoration

The theories outlined in the section above provide a general foundation for understanding the ecological basis for restoration. However, as restoration is inherently practical, the actual significance of ecological theory to restoration ecology can only be fully realised through its application in this context.

There are few examples in the literature where restoration experiments have been established to test a specific ecological theory. Part of this may be because the process for validating ecological models alone is unclear and confusing (Rykiel 1996), or that the conceptual and logistical challenges associated with design and analysis of ecological restoration experiments are seen as insurmountable (Michener 1997). Other reasons may include a difficulty to capture at the observational level, the scale of ecological processes (Ustin et al. 1993), or the complexity of the systems that are involved (Shuwen et al. 2001; Diaz et al. 2003).

There have also been attempts to develop a generalised, universal theory for ecology and biology; Marques and Jørgensen (2001) attempt to explain different empirical biological and ecological observations in terms of a comprehensive thermodynamic hypothesis. Although the approach is robust enough to provide an integrated explanation for the selected set of observations, it is limiting, practically challenging and is still a hypothesis. Expanding on this work, Brown et al. (2004) propose that Metabolic theory predicts how metabolic rate, by setting the rates of resource uptake from the environment and resource allocation to survival, growth, and reproduction, controls ecological processes at all levels of organization from individuals to the biosphere. Examples include: (1) life history attributes, including development rate, mortality rate, age at maturity, life span, and population growth rate; (2) population interactions, including carrying capacity, rates of competition and predation, and patterns of species diversity; and (3) ecosystem processes, including rates of biomass production and respiration and patterns of trophic dynamics. Although Brown et al.'s Metabolic theory is supported by many (Cottingham & Zens 2004; Kaspari 2004; Li et al. 2004; Marquet et al. 2004), others are sceptical about the development of a universal theory that can be applied as an agenda across ecology because of the potential for simplified observations at smaller scales (Cyr & Walker 2004; Tilman et al. 2004). Harte (2004) points out that the Metabolic theory explains a very limited subset of ecosystem traits and fails to incorporate reproductive strategies, succession, stability, food webs, spatial distribution of individuals and species, stochastic and cyclic temporal variability, the influence of disturbance regimes, and organism behaviour. He further adds that the theory fails to address any of the important questions in applied ecology including: What will ecosystems look like under global warming? What sustains and what threatens ecosystem services? How can ecosystems be restored and managed? How can we best design reserves? Nonetheless, Metabolic theory does provide a unique and insightful macroscopic perspective, one that appears to have great utility for comparisons of organisms of vastly different sizes. This could be applied positively in the restoration context, where observing changes in patterns of organisms at the macroscopic level is of

as much significance as understanding smaller shifts. The possible causes of these patterns, the applicability of the approach to studies of similar-sized organisms, and the potential synthesis of mechanistic and macro-ecological approaches are challenges that are likely to be pursued for years to come in restoration.

However, taking into consideration the lack of inclusion of ecological theory in the restoration plans presented in Chapter 2, restoration practitioners may in the first instance require practical instruction on managing the micro-scale restoration context. An ecological model for ecological restoration needs to provide tangible instruction to practitioners on developing and measuring site-specific, practical outcomes.

At the core of ecological restoration, practitioners strive to assist ecosystems to recover more quickly than they might have otherwise done unassisted. It makes sense then, that successional models or models of community development may be the most instructional in providing guidance for practitioners in need of a theoretical basis for guiding action. However, few such models actually provide the kind of quantitative advice that is readily adaptive in the restoration context. In reviewing the literature, E.P. Odum's model of Trends to be Expected in Developing Ecosystems (1969) represents one of the few successional models that could potentially be applied by restoration practitioners.

3.4.1 Odum's (1969) model of Trends to be Expected in Developing Ecosystems

Odum (1969) described trends to be expected in the development of ecosystems (Table 3). This model indicates the progression of 24 key ecosystem attributes as succession occurs from developmental stages to mature stages. The model does not specify temporal or spatial scales in which these trends are expected to occur.

In this sense, despite the fact that the model was based on the deterministic notion that ecosystems reach a mono-climax or poly-climax, there is actually no quantitative suggestion as to when such an endpoint may occur, if at all, or the structural dynamics of such a climax community.

There is flexibility in the model in its capacity to incorporate disturbance theories, since whichever direction a succession moves in, the underlying response process that results will be the same.

Table 3: A Tabular Model of Ecological Succession: Trends to be Expected in the Development of Ecosystems (from Odum, 1969)

Ecosystem Attribute		Developmental Stages	Mature Stages
COMMUNITY ENERGETICS			
1	Gross production/community respiration (P/R ratio)	Greater or less than 1	Approaches 1
2	Gross production/standing crop biomass (P/B ratio)	High	Low
3	Biomass supported/unit energy flow (B/E ratio)	Low	High
4	Net community production (yield)	High	Low
5	Food chains	Linear, predominantly grazing	Weblike, predominantly detritus
COMMUNITY STRUCTURE			
6	Total organic matter	Small	Large
7	Inorganic nutrients	Extrabiotic	Intrabiotic
8	Species diversity – variety component	Low	High
9	Species diversity – equitability component	Low	High
10	Biochemical diversity	Low	High
11	Stratification and spatial heterogeneity (pattern diversity)	Poorly organized	Well-organized
LIFE HISTORY			
12	Niche specialization	Broad	Narrow
13	Size of organism	Small	Large
14	Life cycles	Short, simple	Long, complex
NUTRIENT CYCLING			
15	Mineral cycles	Open	Closed
16	Nutrient exchange rate, between organisms and environment	Rapid	Slow
17	Role of detritus in nutrient regeneration	Unimportant	Important
SELECTION PRESSURE			
18	Growth form	For rapid growth (“r-selection”)	For feedback control (“K-selection”)
19	Production	Quantity	Quality
OVERALL HOMEOSTASIS			
20	Internal symbiosis	Undeveloped	Developed
21	Nutrient conservation	Poor	Good
22	Stability (resistance to external perturbation)	Poor	Good
23	Entropy	High	Low
24	Information	Low	High

3.4.2 Is Odum's model a suitable test case as a model for ecological restoration?

Perhaps one of the reasons why Odum's model has been rarely applied in a practical sense is due to the fact that it has been rigidly associated with the less-favoured climax concepts proposed by Clements (1916). This is true for some studies, where Odum's model has been rejected on the basis of its deterministic foundations, in favour of adopting the mechanistic, individualistic perspective (see Bengtsson et al. 2000).

Initially, Odum's ecosystem model attracted heavy criticism in favour of a population-based approach emphasising the life-history attributes of organisms, the consequence of natural selection, as the essential basis of a theory of succession (e.g. McCormick 1968; Drury & Nisbet 1971, 1973; Horn 1971, 1974, 1975; Pickett 1976; Connell & Slayer 1977). Since then, various ecosystem ecologists not only assert the advantages of an ecosystem concept of succession, but reciprocally, question the theoretical merit and utility of a population-centred approach to ecology and succession (McIntosh 1981), since populations respond in tandem with the ecosystems in which they interact.

Further evidence that trends described by Odum genuinely exist in succession can be found in the numerous studies that have validated their presence. Most recently, Magaeu et al. (1998) designed a model that successfully depicts many of the trends characteristic of ecological succession as outlined by Odum. Similarly, Christensen (1994; 1995), utilised Odum's attributes of ecosystem maturity to quantify maturity in 41 steady-state models of aquatic ecosystems. The results of numerous other studies have indicated correlation with Odum's expected trends for: community energetics (Ohtonen et al. 1999; Aikio et al. 2000; Callicott et al. 1999); community structure (Ohtonen 1994, Ohtonen et al. 1999); nutrient cycling (Knops & Tilman 2000; Ohtonen 1994; Aikio et al. 2000); selection pressure (Ohtonen 1994); and overall homeostasis (Wilhelm & Bruggemann 2000; Ohtonen 1994; Aikio et al. 2000).

The research validating Odum's (1969) trends to be expected in ecological succession is a reasonable indication that this model is an appropriate representation of the process. Odum's model is complementary with both the individualistic and deterministic perspectives that segregate succession theory. Given these two ideas, that the model is an appropriate representation of reality and synthesises the two divergent succession hypotheses, it has been selected as the most appropriate and suitable model for practical application in the ecological restoration context.

3.4.3 How could Odum's model be used in ecological restoration?

From the research undertaken in Chapter 2, it is apparent that there is no consistency in the methods by which ecological theory is incorporated (or not incorporated) into practitioners' guidance for the planning, implementation, or evaluation of ecological restoration. Odum's (1969) model represents a quantitative mechanism for gathering a snapshot of any ecosystem and for understanding at which stage of development it is in. The model enables the user to implement consistent methods for tracking the progress of an ecosystem and would enable greater comparability between studies.

This model could potentially be used as a tool to guide restoration practice, by highlighting to the practitioner the key ecological attributes that require attention and their expected value as the system progresses from developmental to mature stage restoration. The model could therefore be useful as a tool to monitor and evaluate restoration progress.

Chapter's 4 and 5 in this research investigate the practical and theoretical opportunities and barriers that exist in applying Odum's model to the restoration context.

3.5 Discussion: Can ecology provide more for ecological restoration?

Ecology can indeed provide more for ecological restoration. This chapter illustrates the wealth of theory, concepts and models that are not only relevant for paving an understanding of the ecological building blocks that restoration ecologists tinker with, but that serve to promote important questions for restoration practitioners. For example: Are ecological models indeed directly applicable to restoration? If they are, then why is it difficult to find examples of application of these models in restoration management plans and practice (as investigated in Ch 2)? How can ecological models be applied in this context?

In turn, restoration can provide more for ecology by offering an opportunity to test ideas or revisit age-old questions. For example, through restoration, the spatial and temporal scale at which mechanisms operate to drive and control succession may be more readily understood, as restoration sites provide a controlled setting within which to test this. Additionally, restoration projects can build on existing assembly theory by challenging or verifying rules for community assembly and by providing further insight into the pathways or trajectories of community development under different circumstances. Similarly, because restoration involves whole-ecosystems, it offers an excellent experimental context for testing several important ecological questions that have ecosystem-wide impacts, e.g. the age-old diversity debate around numbers of species necessary for adequate ecosystem function; the ecosystem effects of seed limitation, and; the feedback relationships that exist between soil microbes and the wider ecosystem.

Although the opportunities for breaking new ground or finding synergies between ecology and restoration ecology are numerous and exciting, the historical issues associated with establishing ecological theory are important lessons in developing methods for testing ecological theory in the restoration context. Consistent methods are necessary for both determining the ecological theory that is eligible to be tested, as well as the ways in which it will be tested.

Odum's (1969) model provides a framework within which to test succession theory and offers potential guidance to restoration practitioners seeking to understand how ecosystems (ecologically) change throughout the process of restoration. Recalling the lack of inclusion or reference to ecological theory in restoration management plans assessed in Chapter 2, a certain level of care is required in developing Odum's model appropriate for the restoration context; it may be the case that there are specific barriers to practitioners including ecological theory in restoration plans, rather than a lack for want of trying. The use of more colloquial language (rather than technical terms) to describe ecological concepts in the assessed restoration plans may be evidence supporting this idea.

Another challenge that needs consideration is the number of attributes that require measurement in Odum's (1969) model. Of the restoration management plans assessed in Chapter 2, few had any

form of detailed monitoring or evaluation methods in place. Odum's model requires the measurement of ecosystem change across 24 different attributes. While this might provide an excellent cross-section of the pattern of development in restoration, the reality of implementing such measurement may be somewhat idealistic. Further, Odum's (1969) model is limited to assessing the achievement of only ecological goals in restoration; Chapter 2 illustrated that restoration management plans often sought social and cultural goals as well. The economic and political constraints of restoration also proved to be influential in shaping the content, structure and purpose of restoration management plans. These practical challenges are further explored in Chapter 4, where restoration practitioners from New Zealand are consulted on the practical feasibility of applying Odum's (1969) model in the restoration context.

Outside of the practical challenges associated with Odum's (1969) model, it is yet to be established whether or not the actual process of succession is indeed representative of the process of ecosystem development in the restoration context. While Odum's model provides a good null hypothesis to test this, the comparison may not be a fair one, given the social factors governing restoration that are missing in applied ecology. Chapter 5 investigates this further in the theoretical constraints of applying an ecological model to the restoration context.

In short, there is potentially a great deal more that ecology can offer ecological restoration and vice versa. However, a clear and coherent framework is required for establishing restoration projects as experiments and an interdisciplinary headspace is necessary for interpreting the results of such experiments.

3.6 Conclusions

The following conclusions can be drawn from this chapter:

- Although ecological theory is potentially a useful reference for ecological restoration, verification of the models, concepts and terminologies would improve the accessibility and application of ecological theory in the restoration context.
- The ecological theories that have a specific relevance to undertaking the pattern of development that is embodied in restoration include: succession and community development; diversity, stability and function; seed limitation, and soil microbial communities.
- Odum's 1969 model of *Trends to be Expected in Developing Ecosystems* describes the pattern of ecosystem succession across 24 key ecosystem attributes as it progresses from developing to mature stages. This highly-referenced model synthesises two divergent theories of succession and is recommended as the most suitable for testing in the restoration context.
- In order to test Odum's (1969) model in the restoration context, the practical realities that exist in ecological restoration projects need to be taken into account when developing the model suitable for application. This includes consideration of the resources, time and goals of ecological restoration and the potential constraint that these may have in direct application of the model.

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Chapter 4

Practical constraints of applying an ecological model in the restoration context: Odum as a test case

4.1 Introduction

The application of Odum's (1969) model in the restoration context could potentially provide a relatively pragmatic approach to incorporating relevant ecological theory into restoration practice. It could enable the practitioner to 'test' this theory by comparing the actual development of restored ecosystems against that which we understand as ecosystem development in the absence of humans (i.e. Odum's model).

However, consultation with restoration focus groups identified that in New Zealand, restoration projects vary in terms of the support and resources obtainable, the availability and skills of staff/volunteers to implement restoration methods, the ecological focus of the project and thus, the amount of time dedicated to managing the ecological components of the restoration plan. These variables are moderated by social and economic factors that limit the feasibility of using Odum's model as either direct guidance, or as a tool for monitoring restoration progress.

This chapter presents the focus groups' recommendations and suggestions for a more viable approach towards incorporating and testing ecological theory in the restoration context.

4.2 Aim & Methods

Aim

The key aim of this study is to investigate the practical feasibility of applying an ecological model (specifically, Odum's (1969) model of Trends to be Expected in Ecosystem Development) in the ecological restoration context.

Specific questions:

- Are New Zealand restoration practitioners already using ecological models in restoration practice? Is there any consistency?
- Can New Zealand ecological restoration practitioners use Odum's model as a tool for guiding restoration methods or monitoring restoration progress?
- If so, what are the advantages/disadvantages/challenges?
- If not, why not?

Methods

1. Focus groups were regarded as the most suitable investigative tool for conducting this research as it was considered that the topic would promote diverse and complex answers from participants. By running focus groups, it was assumed that this process would enable participants to explore their ideas in greater depth through engagement with other practitioners in the field.
2. An Ethics Research Application was prepared and following submission the study was approved by the University of Auckland Human Participants Ethics Committee on June 8 2005 for a period of 6 years, from 8/6/2005 (Reference 2005/207).
3. It was proposed that each of the focus groups would consist of up to five (normal adult) representatives from the three key sectors involved in practicing ecological restoration in New Zealand, namely:
 - The public sector (e.g. Crown Research Institutes, regional and local authorities, learning institutions).
 - The private sector (e.g. Landscape Architects, Environmental Consultancies).
 - The community sector (e.g. Wai Care, Kaipatiki Restoration).
4. Members of the focus groups were initially approached by direct telephone contact. During this initial phone call, subjects were provided a brief introduction to the researcher and the proposed study and invited to learn more about participation in the focus groups. A Participant Information Sheet and Consent Form were sent to subjects who indicated that they would like to participate in the research (Appendix 1).

5. Two meetings were established for each of the three focus groups (public, private, community sectors). Therefore, a total of 6 meetings took place and each meeting lasted a maximum 2 hours. Meeting no.2 was held one week after meeting no.1. The following broad themes were covered over the course of the two meetings with each group:

Theme 1: Current trends in New Zealand ecological restoration

- How is restoration initiated/promoted within each sector in NZ? (Consider motivations: e.g. obligations under statutory regulations/policy RMA etc; habitat or species protection/conservation; return regional heritage; educational purpose etc).
- Are there any universal NZ protocol or guidelines for initiating a restoration project?
- What is the typical process (by sector) for undertaking a restoration project from start to finish?
- Is there any integration/communication between sectors to feedback results/experiences? Who would be interested in this information?
- Would it be useful to have some specific (general) guidance for undertaking a restoration project?

Theme 2: Using an ecological model to guide and monitor restoration management

- How relevant is ecological integrity to restoration goals within sector specific projects?
- What place does ecology have in ecological restoration?
- Is a model like Odum's (1969) *Trends to be expected in ecosystem development* appropriate for guiding/monitoring ecological objectives in restoration projects?
- How could it be used?
- What are the advantages/disadvantages, challenges/constraints of using a model like Odum's as a reference?

Theme 3: The way forward for progressing restoration management

- Does restoration require some specific guidance/models for best practice?
 - If so, what might they look like? How do we incorporate ecological theory?
 - If not, why not? How can we learn from our restoration efforts?
- What is the best way to collect and share the results of restoration projects between sectors?
- If restoration is a science, should we develop some sound methods for feeding back information between practitioners and scientists and vice versa?

6. All meetings were recorded by audiotape and then transcribed. Themes investigated (above) were coded and transcriptions were allocated codes in order to analyse the common themes and ideas relating to research questions.
7. Focus group results were grouped by practitioner sector within each theme (Appendix 2).

4.3 Results

The following section presents the results of the focus group study.

4.3.1 Current Trends in New Zealand Ecological Restoration

Initiation and promotion of restoration practice

Practitioners in the public sector indicated that the capacity to initiate (and fund) restoration is affected by: (a) whether there is any policy to undertake restoration and; (b) how important this policy rates against others. The language used in the 1991 New Zealand Resource Management Act (RMA) has facilitated policy directed at nature conservation and biodiversity protection, however restoration as a word is not used. Restoration as a terminology has no general definition in the public sector – e.g. ‘restoration’ applied to historical cultural resources means something quite different to restoration applied to historical ecological communities. As a result, restoration lacks formal governance, receives low-priority attention in funding allocations and consequently competes with other sectors e.g. transport, for budget. This is complicated by the fact that it is difficult to quantify and compare the long-term benefits of restoration against the immediate benefits of e.g. getting a new train.

Public sector practitioners felt that the lack of policy around restoration has also lead to confusion within the public sector as to who is responsible for implementing it. As a result, public sector responsibility is essentially granted to the community via the allocation of specific funds that can be accessed by community restoration groups. Community practitioners agreed with this stating that while there was public funding available to support their projects, it was difficult to gain support from this sector in an advisory capacity.

A deficiency in clear policy around restoration exacerbates itself further in the private sector, where often restoration takes place for the purpose of fulfilling a resource consent (*a consent for activity regulated under the RMA. Resource consents include land use consents, subdivision consents, coastal permits, water permits and discharge permits and can be obtained from the responsible public authority through a statutory process*). In the absence of any guiding regulations, private sector practitioners have developed their own methods for restoration. Consequently, there is no consistency in industry practice, and strategy for restoration is regarded by most as the intellectual property of the practitioner who developed it.

The business case for initiating and promoting restoration is poorly understood. One community practitioner observed that “while investing money into restoration of an area of high conservation value may facilitate a more successful ecological outcome than investing the same amount of money in an urban restoration project, the value of engaging and educating the community through urban restoration is not accounted for”. The present system for prioritising areas of high conservation value alone is questionable, as public sector practitioners identified that the existing system does not take

into account the *potential* impact that restoration could have on an area within a 20-year timeframe. For example, Tiritiri Matangi Island was not considered to be an area of high conservation value 30 years ago but is now considered to be a world-leading example of the potential for restoration; the 220 hectare island once farmed and stripped of 94% of native forest has now been restored by volunteers to 60% forest and hosts 78 species of birds (11 species a function of successful translocation) and many of these species are rare or endangered, such as the Takehe *Porphyrio mantelli mantelli* and the Little Spotted Kiwi *Apteryx owenii* (<http://www.tiritirimatangi.org.nz/>). By providing a strong focus on eco-tourism as well, Tiritiri Matangi Island epitomises what restoration should aspire to, as it combines ecological integrity with social values and thereby creates a sustainable relationship for the future.

Reinforcing this ideas, community restoration practitioners emphasised that while money is an important mechanism for initiating and promoting restoration practice, the support of people as a resource is more instrumental. Further, there are different 'triggers' that will stimulate commitment from different groups/communities e.g. Asian community trigger = being a good 'kiwi'; farmers trigger = financial benefits of establishing a carbon sink. These triggers are not well understood, especially those for engaging Maori communities in restoration.

Practitioner's guidelines available and/or utilised.

Practitioners from all sectors were aware of FORMAK (Forest Monitoring and Assessment Kit – an online tool for guiding and monitoring restoration projects and a national database for collecting practitioner's results). However, no practitioners acknowledged that they utilise FORMAK in their own work. Community restoration practitioners highlighted that a lot of practice is required in order to be proficient in FORMAK and the practitioner needs specialist skills in monitoring flora and fauna in order to be able to collect the data that the programme requires. Public sector practitioners agreed that FORMAK is quite complicated and users require some initial training. They also specified a concern that there is no quality assurance in the data that is collected and entered into FORMAK. The general sense from private sector practitioners is that any data collected from restoration projects remains the intellectual property of the practitioner. For this reason, it is unlikely that private sector practitioners would utilise FORMAK.

Among the reasons for the lack of uptake on restoration guidance/tools available, one practitioner from the private sector noted that restoration practice is very site-specific and current guidance is too generalised to be of any practical use. Elaborating on this point further, some public sector practitioners found that the use of generalised restoration guidance meant that some sites would be restored in an ecologically inappropriate manner, e.g. terrestrial trees planted into wetlands; inappropriate planting densities; inappropriate species. In addition, public sector practitioners identified that current restoration guidance is still focused on restoring structure and density rather than ecological processes. Private sector practitioners mentioned that this might be due to the fact that restoration is often implemented for the purpose of mitigation, "prettying up" a site, or gaining a

“rubber stamp” from the council – i.e. outcomes focused on structural, rather than functional success of ecological restoration.

The restoration process on the ground – obstacles and limitations

Private sector practitioners identified that one of their biggest difficulties is developing restoration that meets both ecological and anthropological goals, as these can often be in conflict with one another. For example, restoration for sequestering carbon may not necessarily ensure the biodiversity value of the community being restored. One private sector practitioner believed that the traditional concept of ecological restoration was a metaphor in the modern landscape context – where the term ‘ecological’ should be extended to include humans, given the impact and extent of their influence in shaping landscape ecological processes.

The conflict between ecological and anthropological goals is further complicated by money and time. Both public and private sector practitioners noted that the source and extent of restoration funding and the timeframe to which it was allocated, dictated the scope and agenda of ecological restoration and methods used for implementation.

Private sector practitioners noted that actual restoration outcomes could often be quite different to those anticipated when a restoration site has been left to ‘self-sustain’. Therefore, as results are unpredictable it is difficult to develop models for ensuring successful restoration. Public sector practitioners suggested that following a formalised model for restoration, might be an obstacle to success. It is difficult to account for the ecological variability presented within each restoration site, and methods that are suitable for some will not be suitable for others.

One of the biggest obstacles to successful restoration identified by community practitioners is developing and applying a sound scientific approach, while private sector practitioners specified that on-going physical maintenance of the site was the most critical factor for ensuring successful restoration outcomes.

All practitioners acknowledged that few restoration projects engage in monitoring. Private sector practitioners highlighted that this includes both baseline data as well as tracking projects beyond 5 years from initiation. Apart from instances where restoration is required to meet a resource consent, private sector practitioners admitted that there are no regulatory requirements for monitoring restoration and where project funding is limited, monitoring is the first thing to be cut from the budget. One public sector practitioner stated that monitoring was regarded as ‘research’ and within their sector there was no mandate to take responsibility for (or fund) research on restoration.

Integration between sectors involved in ecological restoration

The general sense from all restoration practitioners was that there is as much integration between sectors as practitioners are prepared to initiate with one another. While community restoration practitioners felt that integration and knowledge sharing between sectors is a necessity and that occurrences are increasing, Public sector practitioners identified that very little integration is occurring, even within their own sector. Private sector practitioners specified that while the need for integration was increasing, most opportunities are restricted to conferences and symposiums. Further, private practitioners identified that few examples of integrated projects are the result of pro-active engagement between sectors; rather they are the result of an obligation under the terms of the agreed contract for the project.

Several ideas were proposed to explain why there is little integration or information sharing occurring between or within sectors involved in ecological restoration. Public sector practitioners believe that it may be because restoration is still relatively young as a science and as a practice, the mechanisms for studying restoration in an experimental manner are not yet established, thus *prohibiting* integration between scientists and practitioners. Further, public sector practitioners felt that the science of restoration currently takes an applied ecology focus and does not recognise people and the economic realities of implementing restoration on the ground i.e. practitioners and scientists do not conceptualise restoration in the same way. Public sector practitioners also thought that because there is no policy around restoration, there is no mandate for integration between sectors involved. In addition they identified that as restoration is very site-specific, practitioners may be less inclined to reach out and help/seek information from one another. There is also a perception within the public sector practitioners that data collected from community restoration projects does not have any quality assurance and is therefore not useful for answering specific research questions that public sector groups want to investigate.

Both private and public sector practitioners specified that there is little integration because sectors only have enough resources to target their own immediate priorities. In addition, private sector practitioners suggested that because restoration is often very piecemeal in its scale on the landscape, there is little need to involve or integrate with other groups in order to achieve objectives. Community restoration practitioners suggested that integration between scientists and practitioners is less prevalent because practitioners do not collect the information that scientists want. Conversely, they also proposed that scientists' line of enquiry is too specific for community practitioners and that integration between these sectors is further limited because scientific enquiry does not generally result in practical implications for practitioners.

4.3.2 Using Ecological Theory as a Restoration Management Tool

Incorporation of ecology within the planning stages of restoration

All restoration practitioners identified that the overall ecological integrity of any restoration is impaired by the involvement *that people* have in the process. Several key types of human involvement were

identified as factors that influence the ecological integrity of restoration: financial commitment to the ecological integrity of the project; aesthetic concepts of ecology to restore; active participation of humans in the process of restoration, and; post-management impact of people on the restored ecosystem (particularly urban sites). Of most concern to all practitioners was the fact that ecological theory does not take into account the roles of people influencing ecological progress through the process of restoration. For this reason, practitioners considered it 'unfair' or 'inappropriate' to directly use ecological theory or models to guide or evaluate restoration projects.

Selected ecological concepts were emphasised as important and pertinent to the restoration context. Landscape scale was identified as one of the key ecological concepts relevant to all restoration; private sector practitioners elaborating that project sites must fit in with the ecological context of the surrounding landscape in order to succeed in the long-term. Linked to this was the concept of connectivity – community restoration practitioners highlighted that this is extremely important in urban areas where project sites are often small and disconnected from ecological sources (such as seeds and birds). Public sector practitioners stated that restoration is often very 'piecemeal', so a focus on the connectivity of these units may facilitate more ecologically useful restoration within the landscape. Ecological function was another concept that was unanimously agreed as important to restoration, particularly in the urban restoration context where it is difficult to prevent the invasion of exotic species to sites. So rather than focusing on restoring a particular ecosystem composition, restoration should prioritise reinstating function e.g. water quality, pollination/dispersal relationships.

Among the ecological concepts that were considered to be difficult to apply in the restoration context, practitioners had mixed viewpoints about eco-sourcing (the propagation of seed or cuttings from populations of locally occurring indigenous plants). Some private sector practitioners thought that eco-sourcing was a very important component of restoration method. Others stated that it may not be so important, as the integrity of eco-sourcing is often compromised by projects that do not allow timeframes long enough for sourcing and propagating the desired species. Community sector practitioners stated that eco-sourcing was less meaningful in dense urban areas where availability of seeds was limited. They also signalled that eco-sourcing should not be applied rigidly in restoration as some species can cross-pollinate readily with others around them (e.g. *Coprosma spp.*), thereby making eco-sourcing less meaningful for these species.

Ecological 'purity' – or the ecological faithfulness of the structure and composition of the restored site compared to the reference ecosystem – was another concept that was considered to be challenging to the restoration context. Community sector practitioners explained that some exotic species are able to fulfil an ecological function in the absence of the desired native equivalent. The decision to remove such exotic species then hinges upon whether ecological purity is weighted as being more important than ecological function. Private sector practitioners added that ecological purity is very much directed by aesthetics and society's requirements for the end product of the restoration.

Ecological unit size and age were considered to be complicated management concepts in the context of restoration. Those in the public sector indicated that while the 'ecosystem' is often the decision-making unit upon which projects are prioritised, patches of all size are important to different species. Private sector practitioners added that while many projects blindly aim to restore a late successional community, they also appreciate that early successional communities might be of equal ecological importance.

All practitioners considered self-sustainability to be one of the greatest ecological challenges to restoration. Public and private sector practitioners felt that it was not achievable, especially in urban areas, as projects of all size require some form of continuous maintenance, albeit minimal pest control. Community restoration practitioners added that in urban areas there are often heavily modified seed banks that inhibit self-regeneration of sites.

One public sector practitioner stated that although ecological theory has not been easily integrated into restoration, increasingly this is changing as society's ecological literacy improves. This facilitates a wider understanding and awareness, and influencing the language used to create policy around restoration.

Incorporation of ecology within the practice of restoration

Although practitioners may have the best intentions to create a restoration that has a high level of ecological integrity, the process itself is one (at least initially), driven by people. As such, restoration projects on the ground are subject to the trials and errors of any human endeavour. In addition, this active involvement in the process of restoration may steer results toward something quite ecologically unpredictable. The following section outlines some of the technical difficulties associated with incorporating ecology within the practice of restoration.

"Restoration is not a natural process – it is an interventionist and human construct. We can learn about seed propagation, interaction between plants, planting densities and ecological processes. We can even keep the big picture in mind, including the social issues of restoration such as labour and transport. But at the end of the day we are developing a new environment and we don't know whether it will work or not." – Private sector practitioner

Community and public sector practitioners agreed that although it did not guarantee the success of a project, the more ecological knowledge practitioners had, the better off they were. They identified examples of projects that were not very successful as a result of the practitioner failing to understand consequences of management action on basic ecological processes, such as food webs (e.g. the restoration of Motutapu Island in the Hauraki Gulf, Auckland, New Zealand). Both sectors agreed that community groups are most subject to a lack of ecological literacy and practical skills. Private sector practitioners suggested that technology such as GIS will help practitioner's to improve methods for

understanding, prioritising and managing ecological restoration by efficiently capturing vast amounts of high-resolution information on landscape scale patterns.

As humans are a part of the restoration process (explained further in Chapter 5), so too are their associated political interests. An ongoing challenge in the New Zealand resource consent process is the conflict between restoration expectations and the reality of results on the ground. Public sector practitioners stated that consent timeframes are often not long enough to enable ecological restoration goals to be met. Further, bonds (financial sum held as security of resource consent commitments) associated with RMA consents are often given back to developers before it is clear that a site can reasonably self-manage. This is largely because resource consents have bonds tied to numbers of species/individuals planted/removed, rather than e.g. system functionality.

Because restoration is occurring in a landscape inhabited by people, private sector practitioners stated that it is difficult to maintain the ecological integrity of restoration sites as they are subject to the influence of the surrounding landscape – whether this is suburbia, industrial estate, farmland – more often than not people are a part of the landscape context. Public sector practitioners also commented on the effect of social values influencing restoration decisions. For example, the removal of trees on the basis that they are a safety hazard to people occupying or using the restoring ecosystem, regardless of the ecological effect of this initiative.

Practitioners' perspectives on the application of Odum's model to the restoration context

Overall, restoration practitioners did not think that Odum's model was directly appropriate for the restoration context.

In terms of the practicalities of applying the model, community restoration practitioners indicated that time and money constraints already limit practitioners' ability to do monitoring or data collection and therefore Odum's model would not be feasible at all. They commented that realistically, community practitioners would only have time/capability to monitor up to 6 basic attributes, rather than the proposed 24 in Odum's model. They further stated that many community practitioners lack the skills to accurately perform the required field and analytical techniques that are needed to put Odum's model into practice. On the technical side, community restoration practitioners felt that Odum's model was only appropriate for bare-ground restoration starting points and would not be able to accommodate the unique ecological circumstances that are presented in urban restoration sites.

Public practitioners similarly thought that Odum's model could not account for human modified landscapes and would only be appropriate for restoration sites where bare ground was the starting point. They commented that this meant the model could not be widely applied in New Zealand as starting points often had some sort of vegetation structure in place, or had been heavily modified by humans in some way. Public sector practitioners also thought that the model could not accommodate

the social complications of restoration, such as dealing with conflicting cultural interests in restoration goals, land ownership rights etc.

Consistent with community sector practitioners' feedback, those from the public sector noted that few practitioners would have the money or labour available to support the implementation of a model like Odum's. Further, they felt that practitioner's did not necessarily need to understand or monitor all 24 ecosystem attributes proposed in Odum's model in order to successfully achieve restoration goals.

Private sector practitioners thought that Odum's model could not be applied in the restoration context because it did not account for other natural changes that occur during restoration over large temporal scales (e.g. geomorphological changes resulting from earthquakes, glacial shift, or climate change). Further, they felt that the model did not account for human involvement in restoration and could not help the user understand the transition between human-driven restoration (early stage) and nature-driven restoration (later stage). One practitioner from the private sector commented that restoration is a very futuristic process and Odum's model involves historical analysis and therefore, does not fit with the focus of restoration.

4.3.3 The Way Forward For Progressing Restoration In NZ

Progressing restoration theory

The following section summarises the key recommendations that practitioners proposed for improving and progressing ecological restoration theory in New Zealand. Ecological restoration theory in this context refers to information, principles and guidance, including tools for monitoring and collecting data. Practitioners commented on the principles and practicalities that require a stronger focus to necessitate a progression in ecological restoration theory. Sector-specific comments are indicated in brackets next to each of the points below (c = community sector practitioners; pu = public sector practitioners; pr = private sector practitioners).

- *Key principles that require a stronger focus to progress ecological restoration theory*
 - Ecological principles:
 - Ecological processes/function – more attention needs to be given to this instead of the present focus on ecosystem structure (c; pr)
 - Landscape/catchment perspective – focus on restoring the ecosystem in the context of functioning within the landscape rather than as a single unit (c; pu; pr)
 - Species ecology – every restoration site presents unique conditions and species have niches such that they will not survive on the site if they are not meant to be there (pr)
 - Self-sustainability – is impossible in urban restoration, as these projects usually require ongoing management in perpetuity. A more appropriate goal

is sustainable function whereby restoration objectives focus on achieving ecosystem function with an acceptable level of ongoing management built in (c; pu).

- Interdisciplinary principles:
 - Aesthetics & ecology – balancing what people want with what works ecologically (c; pr)
 - People & ecosystem relationship – understanding the ecological relationships between people and the ecosystem during the process of restoration (pr)
 - Cultural restoration & ecological restoration – understanding and achieving restoration that can meet cultural and ecological needs.
- *Practicalities that need to be addressed to progress restoration theory*
 - Quality assurance of data (pu)
 - Clear definitions of what encompasses restoration success/failure (pu)
 - Guidance on how to manage people participating in restoration (c; pu)
 - Methodology for prioritising restoration based on restoration potential (pu)
 - Clear pathways for communication and interaction between practitioners and theoreticians (c; pu; pr)
 - Recognition of restoration in terms of its value in 'natural capital' (pu)
 - Greater adherence to the NZ Resource Management Act (pr)
 - Restoration education in schools (pr).

Progressing restoration practice

The following section summarises the key recommendations that practitioners proposed for improving and progressing ecological restoration practice in New Zealand. Restoration practice in this context refers to not only the implementation of restoration projects, but also the mechanisms for interchange of data and information between restoration practitioners and restoration ecologists. Sector-specific comments are indicated in brackets next to each of the points below (c = community sector practitioners; pu = public sector practitioners; pr = private sector practitioners).

Practitioners from all sectors emphasised the importance of people in the practice of restoration and invariably, most recommendations revolved around, or related to improvement in this area.

- Practical recommendations – ecological
 - Landscape context – greater understanding is required regarding how restoration sites fit into the landscape and how the landscape influences the site (c; pu; pr). A dual benefit of this focus would be the inevitable engagement of stakeholders outside of the boundaries of the project site (c).

- Exotic species – focus on functional success rather than removing exotics for the sake of ecological purity. People should also be recognised as an ‘exotic’ to the ecosystem being restored (c).
- Ecological relationships between people and ecosystems – the success of future restoration practice depends on understanding these relationships so that there is a greater opportunity for combining what people want with what is ecologically possible (pu; pr). This philosophy should extend to all sectors involved in landscape modification of any kind e.g. property developers, architects, urban design & planning (pr).
- Practical recommendations – anthropogenic
 - Motivating/engaging people in restoration
 - Emotional engagement – restoration needs to provide people with a sense of emotional attachment and belonging to engage ongoing commitment (pu). Experiences in the natural environment at a young age facilitates this (pr).
 - Sense of ownership/responsibility – will motivate greater long-term commitment from people to a restoration site (pu). “Friends of” groups can stimulate a sense of ownership/responsibility (pr).
 - Direct marketing – ‘sell’ the restoration package to people so that it shows what they can get out of it e.g. benefits: economic opportunities, swimming, art in the park, recreation (pr). Through restoration, people are addressing the welfare of the people as much as the welfare of the land (pu).
 - Communication
 - Training and education – as restoration often involves large numbers of volunteers, the skills and knowledge necessary to progress restoration need to be communicated more widely (c).
 - Meaningful language and concepts – restoration ecologists need to communicate scientific concepts that are meaningful to practitioners (pu) and in language that is understandable to practitioners (c).
 - Keeping projects on track – restoration managers often retire from projects and volunteers turnover with time too, so the goals and methodology of the project must be clearly understood and communicated in order to keep it on track (pu).
- Practical recommendations – economical/political
 - Economic value of restoration – two important considerations are: the economic value of ecology & ecosystem services restored through restoration, and; the economic value of changing someone’s attitude through restoration. Understanding the economic value of restoration will help to communicate the importance of restoration to e.g. government and funders (pu).

- Sector engagement – the value of restoration will be more widely recognised if more sectors are involved, and the relationships between these sectors are understood e.g. community, business, government (pr).

4.4 Discussion: Overcoming the practical constraints of applying an ecological model in restoration reality

Key constraints

This chapter presented the results of a focus group study that investigated the practical feasibility of applying an ecological model to the restoration context. Odum's (1969) model of Trends to be Expected in Developing Ecosystems was selected as a specific example of an ecological model that could potentially be applied to the restoration context.

Although practitioners across all three sectors were enthusiastic and supportive of the concept of applying an ecological model in restoration, a number of practical constraints associated with the application of Odum's model were identified. These included: the time and money required to support implementation of the model, and; the level of expertise necessary to perform field and analytical techniques. Practitioners further identified that the model itself had shortcomings: it was not conceptualised in a way that was understandable to practitioners; attributes of the model were not meaningful to practitioners; social/cultural/political aspects of restoration were not recognised and; New Zealand ecosystems did not follow the trajectories proposed in Odum's model which appears to be more relevant for bare-ground starting points, whereas in New Zealand most starting points have some basic vegetation e.g. retired agricultural grassland, and extant nutrient cycling.

Practitioners also highlighted more general constraints to the application of any ecological model in the restoration context. As a function of the lack of governance and regulation of restoration in New Zealand, practitioners felt that there would be no mandate or incentive to introduce or progress the application of ecological models in restoration. They thought that it would also be difficult to apply a standardised ecological model broadly when the different sectors of practitioners involved approached restoration with their own unique focus – e.g. community practitioners (long-term, holistic focus); private sector-practitioners (short-term, consent/project-bound focus).

The results of this focus group study have revealed that the direct application of an ecological model to the restoration context is in practical terms not feasible. The study has further identified that ecological models may also be conceptually inappropriate for direct application in the restoration context. Chapter 5 discusses the *conceptual changes* within ecological models that are necessary to render them more appropriate for application in the restoration context. The following section focuses on the criteria for overcoming the *practical hurdles* associated with applying an ecological model in the restoration context.

Overcoming the practical hurdles of applying ecological models in the restoration context

All of the practical constraints identified in the section above relate to one key point of difference between ecology and restoration ecology – that is, people. Ecological models do not accommodate this important feature of ecological restoration. It may be possible for ecological models to be applied more readily to restoration if they are adjusted to accommodate the social parameters of human-moderated ecosystem development. The key social parameters that represent practical hurdles to the application of ecological models in restoration are: time; skills/expertise; governance, and; money/resources.

Time constraints limit the ecological goals attainable within the restoration project and the methods used by practitioners to attain and evaluate them. This is perhaps best exemplified in restoration implemented for resource consent, where allotted timeframes are often short-term (<5 years) and goals and techniques focus on numbers of species/individuals introduced/removed, rather than overall system functionality. While it is recommended that this requires review, in reality restoration as a process is designed to be one of urgency, of speeding up natural processes to recover ecosystems faster than they might have recovered unassisted. Practitioners therefore do not have time to observe and measure the complexity of transformations that occur in the restoring ecosystem. Odum's (1969) model identified 24 key measurable ecosystem attributes that change as a system develops; practitioners specified that they only had time to monitor/measure a maximum of 6 of the more basic attributes e.g. total organic matter; species diversity; stratification and spatial heterogeneity (pattern diversity); niche specialisation; mineral cycles, and; growth form.

The simple recommendation is that ecological models designed for ecological restoration provide no more than 6 key measurable goals and/or parameters for practitioners to implement and evaluate. But which ones are key and how are they best measured? One of the major concerns identified by practitioners in this research related to quality assurance of restoration data collected by different sectors involved. Studies have shown that ecological sampling and monitoring techniques can greatly influence practitioners' perception and interpretation of whether restoration goals have been achieved (Korb et al. 2003; Shuman & Ambrose 2003). Therefore, the selection of key ecological attributes appropriate to restoration requires careful consideration. Attributes need to be easily and effectively measured by all sectors of practitioners involved in restoration whilst providing accurate representation of the ecological changes taking place.

Expertise in ecology and ecological sampling skills vary between sectors of restoration practitioners. This can limit practitioners' capacity to understand ecological models in the context of restoration and therefore, their ability to implement or apply models in practice. Cairns (2000) emphasises the importance of ecological literacy in helping people to understand both how ecosystems can be damaged, but also, how they should best be repaired or restored. Two major mechanisms for improving ecological literacy amongst New Zealand practitioners are through education and communication. Participants in this study identified that they require more opportunities to increase their ecological knowledge and skills; some suggesting that this could be a fundamental component of

science curricula in schools. Furthermore, while more opportunities for learning are valuable, how ecological concepts are communicated to practitioners is crucial. Ecological concepts and models need to be communicated to practitioners in language and terms that are relevant and meaningful to the actions that take place in restoration on the ground. At the same time, by increasing ecological literacy amongst practitioners, it may be possible for theoreticians to collect more scientifically meaningful data from restoration projects. The development of two-way pathways for communication between restoration ecologists and practitioners will enable more rapid progression of restoration as a science and as a practice.

The lack of policy to govern or regulate restoration practice in New Zealand means that there is no requirement for practitioners to adopt ecological models within their projects, or recognition of who is responsible. While the economic value of restoration remains un-quantified, restoration remains low priority and subsequently, does not prompt any significant financial investment from government. As a consequence, practitioners find no incentive to utilise their limited resources in the application of ecological models in restoration practice. Kennedy et al. (2001) describe emerging approaches to environmental policy in Europe and the USA that entail integration of ecological and economic development concepts. This is perhaps a good model for how restoration policy can be best materialised in New Zealand – by tying it to policy around sustainable urban design, conservation and biodiversity, catchment/watershed management, or rural economic development. This requires that the economic benefits of restoration be quantified. Kenyon & Nevin (2001) propose an approach to quantifying the economic value of forest restoration projects that incorporates an economic evaluation of the willingness of people to participate in the project. Therefore, quantifying the economic benefits of restoration should include consideration of both the ecological and social values.

The resources available to projects can often limit the scope of restoration objectives. Resources include access to funding, people and information and technology. Of these, people are perhaps the most important resource driving the success of restoration projects. People are also the only resource capable of applying ecological models in restoration practice, and therefore, it is necessary to focus on methods to encourage and engage more people in restoration practice. This in part relates back to a previous section regarding enhancing practitioners' ecological knowledge and expertise, but this may not serve to engage others in the first instance.

People are a crucial ingredient in restoration, therefore the benefits of their involvement need to be recognised. Practitioners in this study identified that people needed to feel they were 'getting something' for their investment in restoration, that the ecological benefits of restoration were simply not seen as direct benefits to people. Practitioners proposed that more people would be interested in restoration if ecological benefits were 'packaged' to show how they benefited people e.g. clean water – for drinking and swimming; biodiversity – for aesthetics, education, recreation. This does not mean that the ecological integrity of restoration needs to be compromised; it is rather a means of 'selling' restoration to people in a way that is meaningful to them.

Providing individuals with a sense of ownership and responsibility for their part in restoration may serve to connect them with a site and engage their long-term commitment. Bray et al. (2002) demonstrate that improved stewardship of Mexican forest resources has been achieved through the transfer of their management to the local communities. The culture-landscape connection also needs to be considered in this context, as different cultures may have specific interpretations for 'ownership' and 'responsibility' of the landscape. Kimmerer (2000) postulates that reinstating a 'pre-settlement equilibrium' in restoration is impossible without understanding the relationship between the indigenous inhabitants and the land. Furthermore, even where legislation exists to promote bi-cultural management of landscapes (such as in the New Zealand Treaty of Waitangi 1840), real partnerships depend on understanding and demonstrating inclusion of cultural values and equity (Taiepa et al. 1997).

While the practical constraints associated with implementing an ecological model in restoration are distinctive, they are not independent of one another. Restoration governance affects the resources available and responsibility for restoration and this in turn impacts upon who manages restoration, their level of skill and expertise, and the amount time spent managing projects. In the end, the success of applying ecological models comes down to the ability of people to adopt and adapt them within the social parameters of human-moderated ecosystem development.

4.4 Conclusions

The practical constraints identified in this chapter are not limited to the application of Odum's (1969) model in the restoration context. Practitioners identified that time, resources, governance, and skills are challenges that all practitioners would face in applying any ecological model that does not recognise the realities of restoration on the ground.

Ecological models appropriate for restoration need to fit in with or advocate clear policy and procedures for restoration governance and responsibility. Models need to be communicable to practitioners yet provide enough scientific integrity to offer meaningful results to restoration ecologists. Finally, ecological models appropriate for restoration need to be sensitive to the resources, expertise and time available to practitioners responsible for managing restoration projects.

By incorporating these practical considerations in the development of ecological models appropriate for restoration, a pathway towards testing ecological theories in restoration practice becomes more apparent and feasible. This will facilitate improved understanding regarding the relevance of specific ecological concepts and their adaptation in the restoration context. These conceptual issues will be discussed further in the following chapter.

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Chapter 5

Theoretical constraints of applying an ecological model in the restoration context

5.1 Introduction

The previous chapter illustrated that the application of an ecological model as a tool for guiding or measuring restoration progress is impractical due to the level of support and resources necessary to provide for capital costs, the considerable technical expertise required of staff/volunteers available to implement ecological methods, the amount of time needed to develop methods, collect and analyse data, and the complexities of who is governing/commissioning the restoration.

Outside of these practical difficulties, ecological models, such as that developed by Odum (1969), do not account for the physical involvement that humans have in the process of ecosystem development in restoration. This is a fundamentally important difference between ecological succession in restoration and ecological succession in the absence of human involvement ('natural succession').

Ecosystem development in restoration is at least initially, largely manipulated by people, rather than by abiotic and biotic forces alone. There has been little research undertaken to explore how restoration activities impact upon or add to the extant ecological processes operating within a restoration site. Consequently, ecological restoration may not be so much an acid test of our understanding the functioning of ecosystems, but rather, an acid test of our understanding mutually beneficial interactions between humans and ecosystems (Burke & Mitchell 2007).

This chapter explores how human 'assistance', provided through restoration, impacts upon or adds to the extant ecological processes operating within a restoration site and then endeavours to illustrate how restoration participants inadvertently become additional ecological players in the ecosystem structure. The trophic roles of human participation in the natural system are presented and examples are provided that illustrate the ecological consequences of restoration management actions on biotic and abiotic components.

5.2 The limitations of convention

Ecological restoration is “the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed” (SER 2004). By its very definition, ecological restoration is a process by which humans are implicitly involved – through ‘assisting’ ecosystem recovery.

Conventional ecological theory that has been applied to ecological restoration, such as: succession and community development; diversity, stability and function; seed limitation, and; soil microbial communities (as presented in Chapter 3), typically describes ecological processes and systems that exist and operate in the absence of humans.

The question of whether or not it is appropriate to apply conventional ecological theory directly to restoration is pertinent. Although humans may not consistently be involved for the duration of the restoration process, their participation, especially in the initial stages of ecological restoration, is designed to manipulate the abiotic and biotic conditions of a system in order to steer it towards a desired ecological trajectory. Because conventional ecological theory does not account for this important role of humans, the extent to which it can be directly applied to the restoration context may be limited.

Consider the following analogy: If a new species introduced to an ecosystem served to increase habitat diversity, increase habitat size, remove populations of other species in the system, change the energy dynamics, and decrease chemical pollutants; a model of that system would need to include description of the new species in order to connect the indicative changes to their source of impact. In ecological restoration, the effects described above are just some of the consequences on ecosystems that can result from the actions of humans. Therefore, a conceptual model to describe ecological restoration should include the roles and impacts that humans have on the conventionally understood process of ecosystem development.

Yet the prevailing methodology of practitioners relies upon the theories of community succession and ecosystem development for models of how restoration sites will change through time (Zedler & Callaway 1999). Much of the predictive capability for the hypothetical developmental pathways developed in restoration models is qualitative (e.g. Magnuson et al. 1980; Bradshaw 1984; Kentula et al. 1992; Hobbs and Mooney 1993; Dobson et al. 1997) and indeed, while there are few, if any peer-reviewed cases of restoration projects actually following predicted trajectories, several studies illustrate cases where restoration does not assist any clear directional changes toward a target community (e.g. Briggs et al. 1994; Simenstad & Thom 1996; Zedler 1996; Zedler & Callaway 1996).

What then of the application of Odum's Trends to be Expected in Developing Ecosystems to restoration? In presenting the model in the well-known 1969 *Science* article, Odum's primary motivation was to provide people with a scientifically-sound method for understanding the balance of

ecosystems and their capacity to support human life. Odum uses the model to emphasise that society's wholesale extraction of resources ('maximum production') cannot be supported by ecosystems, which tend towards low-production, 'maximum protection' systems as they evolve. He proposes that a balance must be reached between man and nature, either through a 'compromise' relationship – moderate production and moderate protection, or through a 'compartmental' style relationship – simultaneously maintaining highly productive areas and protective types as separate units subject to different management styles. Although the compromise relationship may be one that is more sustainable, Odum's concept of a compartmental relationship appears to be the prevalent method adopted by humans attempting to protect their environment today.

While the intention of Odum's article is laudable, if not somewhat ahead of its time, it fails to capture a critical aspect of the desired outcome – that in order to develop a compromise relationship, people need to understand how they are a part of the system in order to strike a balance. Odum's model shows ecological attributes that develop in the absence of people. Whether it is extraction, deposition, protection, or restoration of ecosystems that is desired, people are a part of the ecosystem development/deterioration process. A model that sets out to show the balance of life that is achievable needs to include humans as a species, a participant in the system. This may be somewhat idealistic, since human interaction with the environment depends upon more complex social parameters such as cultural adoptability, economic viability, social equitability, and political relevancy (Linehan & Gross 1998). Many of these social factors relevant to restoration are identified in the preceding chapter and will be readdressed in Chapter 6. However, the present chapter establishes an appreciation of the general activities initiated by people in ecological restoration and attempts to qualify these in terms of their ecological effect and subsequently, what this means in regards to the basic ecological roles of humans in restoration.

5.3 People as an ecological component of restoration

The concept that people are an ecological component of our planet is not a new one. Lovelock and Margulis' Gaia hypothesis (1974) served to provide a contentious (and disputed) theory that the Earth System is a superorganism, of which humans are a component part. The Gaia hypothesis advances three central propositions: (1) that biologically mediated feedbacks contribute to environmental homeostasis; (2) that they make the environment more suitable for life; and (3) that such feedbacks should arise by Darwinian natural selection. Unfortunately, while the hypothesis can explain conventional trophic relationships and the feedback mechanisms that serve to regulate the balance of life, humans as a species have found ways to bypass biological limitations and natural selective processes. The net result is a destabilisation of biological feedback mechanisms that would normally facilitate homeostasis, and this then may serve to amplify, rather than dampen global problems such as climate change. For example, it is estimated that around 14 million acres of Spruce trees *Picea spp.* in Alaska and British Columbia have been killed by bark beetles, whose rapid spread was once slowed by colder and warmer winters (Berg et al. 1999). The loss of trees on a massive scale means less carbon dioxide can be removed from the atmosphere, which in turn feeds back into the problem of global warming. Furthermore, if natural selection can maintain some integrity through a human-dominated system, it favours any trait that gives its carriers a reproductive advantage over its non-carriers, regardless of whether it improves or degrades the environment (Kirchner 2002). For example, with the warming of the earth, some 30 'new' diseases have emerged since the 1970's and the vectors for these diseases, such as mosquitos, lice and ticks are spreading into new locations and across new ranges (Epstein et al. 1998).

We are not naïve to the detrimental effects that humans have on our planet. Over the years, research projects have documented the many and varied effects that humans can impart on a range of communities, either through deliberate or inadvertent interaction. For example, in their trampling experiments on rocky shallow communities, Milazzo et al. (2003) observe that the recovery rates of two competing species of marine algae vary depending upon the level of impact associated with human trampling disturbance. Similarly, in a four-year study of human trampling disturbance on arctic tundra communities, Monz (2000) observed that these communities can tolerate only moderate levels of disturbance – plots where only low and moderate levels of trampling were applied returned to pre-disturbance conditions by four-years after trampling. In their study of the effects of nature trails on vegetation colonisation, Bhujju and Ohsawa (1997) found that the soil compaction resulting from human trampling deterred vegetation succession by inhibiting root development and stem growth of understory colonisers.

The effect that humans can have on bird communities has also been well studied (e.g. Stalmaster & Newman 1978; Bélanger & Bédard 1989; Pfister et al. 1992; Reijnen et al. 1995). Lord et al. (2001) investigated the effects of human disturbance on the nests of the New Zealand dotterel shorebird *Charadrius obscurus aquilonius* using three types of approach to nests – walking, running and leading

a dog. While walking and running resulted in birds showing a similar level of avoidance response, the dotterels perceived the dogs as posing more of a threat. Similar results were found in Thomas et al.'s (2003) Californian study testing the impact of human recreational use on the foraging behaviour of sanderling shorebirds *Calidris alba* – while humans activity significantly reduced the amount of time sanderlings spent foraging, the most significant negative factor was the presence of free running dogs on the beach. In their European experiments on the effects of human disturbance on oystercatchers *Haematopus ostralegus*, Verhulst et al. (2001) demonstrated that human disturbance reduces the amount of time oystercatchers spent foraging and the level of parental care provided to chicks. The impacts of humans are not limited to shorebirds, nor are they the same for a given species; Fernandez-Juricic & Schroeder's (2003) research on spot-winged pigeons *Columba maculosa* and eared doves *Zenaida auriculata* in Argentinian woodlands observes that vigilance behaviour (scanning for danger) can affect the distance at which birds detect human disturbance – more vigilant birds have a higher probability of detecting visitors and may therefore have a lower tolerance to human disturbance. A study by Miller and Hobbs (2000) illustrates the cascade effect that human activity can have on bird populations. In their research into the effect of recreational trails on nest predation in lowland riparian sites Miller and Hobbs found that birds attacked more nests near trails than away from trails, whereas mammals appeared to avoid nests near trails. Their study demonstrates that while human activity can directly influence the nesting success of some bird species, it also affects the dynamics of nest predation patterns, thereby causing a further (indirect) impact on nesting success.

These indirect effects are known as 'trophic cascades', which result in inverse patterns in abundance or biomass across more than one trophic link in a food web (Carpenter & Kitchell 1993). Trophic cascades result from the removal of higher trophic levels, shifting dominance and impact of consumers to lower levels. Pace et al. (1999) describe several examples of trophic cascades existing within diverse ecosystems. Among the most well understood trophic cascades are those involving the interaction between humans and coastal marine ecosystems. Harvesting marine organisms can affect not only the organisation and structure of entire marine communities, but also their susceptibility to natural events (Sala et al. 1998). Castilla (1999) scientifically tested whether functional food-web theory and paradigms, derived almost exclusively from the interplay among and between non-human organisms, can be used to assess human ecological roles in marine ecosystems. By using human-exclusion experiments, Castilla demonstrated that functional trophic-web predictions do apply to humans if they are included as a top predator and he further developed a food web model that incorporated their role as a predator in the Chilean mid-intertidal functional food web (Castilla & Durán 1985; Castilla & Bustamante 1989; Durán & Castilla 1989; Castilla et al. 1994; Castilla 1999).

The roles of humans in restoration

While the detrimental or 'predatory' relationship that humans have with our planet is generally accepted and well-represented (as above), there is no evidence of research regarding the potentially positive, or mutualistic human-environment relationships that may exist for example, during restoration.

Through restoration, humans are offering nature some assistance towards recovering an ecosystem's structure and function, but whether or not the result of such efforts is perceived to be 'positive' or 'successful' is dependent upon desired ecological trajectories or pathways set at the outset. The difficulty here is that desired trajectories are determined by humanity's limited and contradictory understanding of ecology and therefore, what people expect to restore may be somewhat different to what can be restored. Examples have already been presented that illustrate restoration projects that did not lead to desired directional changes toward a target community (e.g. Briggs et al.1994; Simenstad & Thom 1996; Zedler 1996; Zedler & Callaway 1996).

Whether the relationship between people and ecology during restoration is perceived to be positive or negative is arbitrary; what matters is that a relationship exists nonetheless. It is not feasible to exclude people from an ecological model of the restoration process.

The techniques which are employed during restoration, such as planting, weeding and pest removal, serve to underpin the dynamic interaction between people and ecology. Although the intention of restoration may be for one of mutual benefit, by understanding the trophic implications of these various restoration techniques it may be possible for this relationship to be realised quantitatively. The following table summarises the key actions implemented by people during restoration, their direct ecological effect on the ecosystem and the possible ecological roles that are implied through this process.

Table 4: The Ecological Consequences of Activities Implemented by People During Ecological Restoration (Adapted from Burke & Mitchell 2007)

Restoration technique	Effect on ecosystem	Proposed ecological roles of humans in restoration
Establishing vegetation (planting)	<ul style="list-style-type: none"> Increases species diversity Alters spatial structure and size Increases competition Facilitates fixation of minerals and gases e.g. nitrogen, carbon dioxide Increases biomass Alters site microclimate 	Disperser Facilitator Transformer
Introducing fauna (translocation into site)	<ul style="list-style-type: none"> Introduces additional trophic participant 	Vector
Introducing organic matter (mulching/fertiliser/nutrients/biomass)	<ul style="list-style-type: none"> Increases quantity and availability of system minerals & nutrients 	Decomposer
Removing vegetation (weeding/burning/thinning)	<ul style="list-style-type: none"> Reduces system biomass Alters interspecific competition Affects soil microclimate & composition 	Herbivore Facilitator Transformer
Removing fauna (pests, translocation out)	<ul style="list-style-type: none"> Modifies trophic web 	Predator/carnivore (pest removal) Vector (translocation to other site)
Excluding fauna (fencing site)	<ul style="list-style-type: none"> Excludes trophic competitors 	Competitor

Examples of the direct ecological consequences of various restoration activities are represented in the literature:

Establishing and removing vegetation

Lee et al. (2006) show that the biological integrity and ecological stability of an air-pollution damaged forest in South Korea improves by planting pollution-tolerant species. Gomez-Aparicio et al. (2004) found that planting under shrubs in the stress-prone Mediterranean basin increases the facilitation effects and aids in the survival of planted seedlings. Further, Rodriguez (2006) builds a case to prove that maintaining invasive species can actually facilitate native species restoration through habitat modification, trophic subsidy, pollination, competitive release, and predatory release. In a study of the effects of intense prescribed fire on understory vegetation restoration in a mixed conifer forest of the Grand Canyon National Park, Huisinga et al. (2005) found that although burning caused a temporary reduction in overstory canopy cover and duff (organic matter) depth, plant cover was nearly twice as great in the burned site than in the unburned site after two years and after 8 years, was 4.6 times as great. The study also showed that burned sites increased average and total species richness.

Introducing organic matter

Adding organic matter such as mulch, fertiliser, nutrients or biomass is designed to support and enhance the potential for successful restoration. Eranen & Kozlov (2006) found that in heavily polluted, barren landscapes in Russia, addition of lime can help to reduce soil toxicity and improve seedling performance and survival. In the restoration of streams in central Europe, introduced large wood (logs) can facilitate successful restoration by improving the hydromorphological state of the stream (Kail & Hering 2005).

Introducing/removing/excluding fauna

The direct consequences of introducing, removing and excluding fauna in restoration can be significant. Banks (2000) study on the effects of removal and introduction of red foxes (*Vulpes vulpes*) on the population of European rabbits (*Oryctolagus cuniculus*) in montane Australia showed that while rabbit populations decreased when foxes were introduced, their population may escape regulation by foxes once they reach a critical density. In a study of the recovery of bush rat (*Rattus fuscipes*) populations in forest fragments following major population reductions, Lindenmayer et al. (2005) found that despite widespread removal, rat populations recovered to pre-treatment size within two years. Furthermore, they found that population recovery was mostly via residual animals (and their offspring) that escaped capture, rather than colonisation from neighbouring populations. This has implications for vegetation habitat management where parts of habitat fragments that escape disturbance, or are partially disturbed, may continue to support suitable habitat and be a source of rats. In Jackson's (2001) study, the effects of excluding invasive hedgehogs (*Erinaceus europaeus*) on populations of wading birds (*Charadrii*) in Western Isles of Scotland are presented. Jackson observed that by excluding hedgehogs from wading bird habitat by initially trapping hedgehogs, then fencing the site, wading bird nest success increased approximately 2.4 times.

The table and examples above illustrate some of the immediate ecological consequences of restoration activities, but these effects can cascade along the trophic chain causing wider impacts on the ecosystem. For example, Wightman & Germaine (2006) showed that by increasing herbaceous ground cover and Gambel oak (*Quercus gambelii*) densities in southwestern United States forests, invertebrate assemblages increased, thereby improving forage abundance for nesting bluebirds (*Sialia mexicana*). Brooks' 2001 research on the effects of removing overstory hemlock (*Tsuga canadensis*) in northeastern America showed that with hemlock removal, understory vegetation subsequently responded vigorously which in turn caused the relative abundance of eastern redback salamander populations to temporarily decline. In Wardle et al.'s (1998) study of the ecological effects of wildfires in the recovery of northern Boreal forests, they found that the charcoal produced by wildfires serves to stimulate soil microbial activity, which in turn stimulates decomposition of litter. Further, as charcoal absorbs secondary metabolites such as humus phenolics (which retard nutrient cycling and tree seedling growth), regeneration of trees is enhanced.

In many cases, the ecological consequences of restoration activities are dependent upon the site conditions, or the way in which the treatment (activity) is implemented by the practitioner. For example, in their investigation of the impact of intense wildfire on soil processes in southwestern ponderosa pine forests in the United States, Grady and Hart (2006) propose that nitrogen mineralisation rate is positively correlated to the level of carbon in soils resulting from wildfire; high carbon input can result in high nitrogen cycling rate and conversely, a low carbon input results in a low nitrogen mineralisation rate. Lee et al. (2006) found that application a sludge fertiliser to assist in restoration of air-pollution damaged forest in South Korea was more effective on bare-ground and forb sites, rather than grassland as the former had lower organic matter content. Adams and Galatowitsch's (2006) research highlights the importance of timing in determining the effectiveness of restoration techniques. Their research on reed canary grass (*Phalaris arundinacea* L.) control in wet meadow wetlands of the United States found that application of glyphosphate herbicide in late August and late September were far more effective than in mid-May (due to enhanced glyphosphate translocation to rhizomes), such that two mid-May applications reduced *P. arundinacea* biomass to a level equivalent to that achieved by one late-season application. The way in which herbicide is applied can also influence the effectiveness of the treatment. This is best illustrated in Cornish and Burgin's (2005) study on the effects of glyphosphate spray on four Australian species, which found that the volume of spray delivered using hand-operated sprayers varied between operators by 5- and 10-fold to complete the same task – at the high end presenting a potential risk to the most tolerant species.

Finally, while the ecological consequences of restoration are influenced by the nature of the site and the restoration participants, the shape and extent of restoration activity is inevitably limited by social parameters, such as the financial boundaries of the project. Taylor and Hastings (2004) propose two different 'optimal strategy' for controlling *Spartina alterniflora* in Washington, USA, depending upon the

annual budget available for control – with a higher budget, the optimal strategy involved prioritising high-density areas which produce large quantities of propagules whereas with lower budget, the optimal strategy was to prioritise low-medium density areas which produced less propagules but spread faster vegetatively.

All of the examples described above realise that restoration activity has tangible ecological consequences. However, the ecological trajectories resulting from restoration are not usually evaluated against comparable restoration projects, but rather, more generally accepted successional models of ecosystem development in the absence of humans. But why should restored sites develop in this way, given the level of human intervention that restoration entails? The applied ecological succession model is an unfair benchmark and an unfair target. The experimental nature of restoration needs to be fully realised, and this includes exploring and categorising the complex ecological relationships that result from human participation in this process.

5.4 Discussion: Towards building a conceptual restoration model

Incorporating the activities of humans in conceptual restoration models does not detract from the fact that ecological restoration is still an ecological process – merely, that people are a part of that ecological process. This approach provides a scientific method by which to incorporate the decisions and choices that people make in their restoration activities and thus enables a greater amalgamation of values and science. Restoration ecology can therefore be clearly distinguished as a science and as such, a very unique branch of Ecology.

Ecological restoration is the backbone of restoration ecology, providing the necessary catalyst for shaping restoration theory and challenging assumptions. Ecological restoration is perpetually experimental – there is no conclusion point at which people cease to learn anything further from an individual project. Ecological restoration will always involve people interacting with ecology, regardless of whether this is to fulfil social, cultural, political, economic or ecological objectives. Thus, ecological restoration is an acid test of understanding the mutually beneficial interactions that are achievable between people *and* ecology.

Ecology and people as one

In light of the trend towards sustainability, there is an increasing awareness of the need to recognise ecosystems as a whole – including humans as a member of what would have previously been understood as the ‘natural environment’, or ecosystems thought to operate mutually exclusive of people. Liu (2001) proposes that as most ecosystems are human-modified, an integrated approach that incorporates human demography, behaviour and socio-economics is required in order to understand and manage ecological patterns and processes. Mitchell and Craig (2000) highlight the need to integrate conservation and production into the same set of paradigms. In line with Odum's concept of compartmental relationships with nature, Noble and Dirzo (1997) address sustainable forest management, suggesting that as all forests are human-dominated to some extent, sustainable management will involve interspersing intensive use areas with those used for conservation and catchment purposes, with a critical need to develop a whole-landscape management perspective. Similarly, Piussi and Farrell (2000) propose multiple-use management of forest ecosystems as a means of enabling the mutual provision of ecosystem services for humans balanced with provision of ecosystem stability. This philosophy extends beyond forest ecosystems; James (2000) postulates that successful beach management in the future will require that beaches are considered multi-dimensional environmental systems – ‘beach environments’ – that are nested within larger coastal systems and comprised of interacting natural, socio-cultural and management systems.

As a means towards incorporating people within conceptual ecological models, it is also useful to consider how human systems can be understood in ecological terms. Savard et al. (1998) apply concepts relating to biodiversity management such as scale, hierarchy, species identity, species values, and fragmentation to biodiversity of urban environments. They suggest that the application of

these concepts in such artificial ecosystems may yield important insights for the management of natural ecosystems. Similarly, Alberti et al. (2003) see urban environments as emergent phenomena of local-scale, dynamic interactions among socio-economic and biophysical forces. They state that a reductionist approach – studying humans and ecology using alternate complex systems theory – cannot explain how human-dominated ecosystems emerge from interactions between humans and ecological processes. Proposing an integrated framework, Alberti et al. (2003) describe how it is possible to test formal hypotheses about the way in which human-dominated ecosystems evolve from these interactions. The use of terminology to describe human/ecological systems can sometimes become confused; Warren and Harrison (1984) criticise the mistreatment of ‘biogeography’, highlighting that by conventional definition, it is the study of the real nature of the relationship between people and ecosystems. They postulate that many biogeographical studies actually investigate ecological relationships so that inevitably, the dynamic total people-ecosystem relationship becomes understood in parts, rather than as a whole e.g. acid rain, desertification. In studying biogeography in its purist sense, Warren and Harrison (1984) suggest that this will provide more important insights into ecology than the study of ecological relationships on their own. Fraser *et al.* (2003) also recognise that the study of people and environment has tended to focus on how one affects the other, rather than the interaction between the two. They propose a method for studying this reflexive relationship that looks at the mutual vulnerability and mutual dependence of society and environment.

The necessity to understand the integration between ecological and human systems may be more driven by socio-economic motivation than scientific curiosity. Szaro et al. (1998) emphasise the need to improve the interface between social, economic, physical-biological and ecological models as a basis for understanding more accurately how resources and ecosystem services can be best managed. Nuppenau's (2002) research looks into the quantification of a genuine exchange value of nature in order to facilitate better representation of nature in human planning. His model is among many in the field of ecological economics that recognises a need to understand not only the ecology-people relationship, but also what this means in economic terms so that it can be fed into conventional methods of resource quantification (e.g. Pearce & Turner 1990; Freeman 1993; Pearce & Moran 1994).

Towards conceptual ecological restoration models

In their paper on developing ecological restoration as a real-world experiment, Gross and Hoffman-Riem (2005) state that human participation has to become part of the scientific work, rather than seen to be undermining the power of science. They propose that ecological restoration represents a new understanding of science, where the traditional boundary is no longer the boundary between science and non-science, but that between a sensitive, ‘natural’ science and a removed, ‘unnatural’ science. Özesmi & Özesmi (2004) take an initial step in developing an ecological model that incorporates people's knowledge. They present a multi-step fuzzy cognitive mapping approach to develop a qualitative ecological model that enables the uncertainty and complexity of human-ecology relationships to begin to be incorporated.

Regardless of whether or not the technical role of people can be incorporated into a conceptual restoration model, Geist and Galotowitsch (1999) speculate that it is the social constraints of restoration, such as cost, limitations in land allocation, and insufficient time and labour that are the biggest obstacles to the progression of restoration ecology. They suggest that as humans are such an important part of restoration, overcoming these social obstacles is critical to people remaining committed and interested in the restoration. When a project becomes entangled in social issues, ecological goals are less likely to be achieved. This is disheartening for the people participating in the restoration, who may become disinterested and less committed to the project, which further feeds back on the capacity to achieve ecological goals. Geist and Galotowitsch (1999) propose a reciprocal model that suggests ecological restoration goals are most likely to be achieved when participants develop expertise and leadership, group cohesiveness, and a sense of personal reward.

From the above it is clear that while there is a need to understand the ecological role of human participation in restoration, the complexities of social factors such as goals, resources, politics, ownership and responsibility need to be well understood. These factors are the drivers of restoration action and therefore, in moving towards building conceptual restoration models, the relationship between drivers and action could be explored. In any event, the actual classification and quantification of the ecological impact of people's restoration actions is still required. Therefore, it is recommended that future restoration research or experiments begin to investigate this using scientifically valid methodology. These ideas will be explored further in the following discussion chapter.

5.5 Conclusions

People who are involved in restoration are 'ecological participants' of the developing ecosystem as restoration activities impact upon the biotic and abiotic components, both directly and through trophic cascades. Restoration activities - such as establishing and removing vegetation, introducing organic matter, and introducing, removing, and excluding fauna – all have an effect on the structure and/or function of the ecosystem undergoing restoration. These effects include increasing/decreasing system biomass, changing trophic dynamics, altering competition, modifying ecosystem microclimate, and increasing the quantity and availability of minerals and nutrients. This implies that humans have various ecological roles in participating in ecological restoration including: disperser; facilitator; transformer; vector; decomposer; competitor; herbivore, and; predator.

Therefore, the application of conventional ecological models to the restoration context is inappropriate, since these models are based upon the development of ecosystems in the absence of humans. Odum's succession model (1969), depicting the trends to be expected in developing ecosystems is one such model and although the purpose of the model was to enable humans to understand how to balance their livelihood with the balance of nature, the environment is still treated as a separate, self-managing entity.

Ecological theory is by no means redundant in serving to develop the conceptual restoration model – it is in fact the foundation upon which to expand from. The next stage is to incorporate humans as a 'species' or ecological player and to quantify the effects of various restoration activities.

The ecological effects of a given restoration activity may not be consistent or predictable between sites, since each site presents a unique combination of ecological conditions and the methodologies for implementing activities will vary between practitioners. Furthermore, the social constraints of restoration, such as resources, skills and time will determine how much people will be involved and for how long. Indeed, it is therefore possible that the 'best practice' conceptual restoration model will vary depending upon the social conditions that govern the operation.

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Chapter 6

Discussion and Recommendations:

A new paradigm for progressing restoration research and practice

6.1 Introduction

This final chapter draws together the research in those preceding and discusses the opportunities for progressing restoration as a science and a practice going forward.

The state of restoration ecology today is presented. This discusses the complex social layers that contribute to current problems in the theory and practice of restoration, in the context of a world where restoration is becoming of greater interest. This section integrates the research and findings presented in Chapters 1 – 4.

Drawing on insights from Chapter 5, the importance of understanding restoration practice as a fusion of humanity and ecology is discussed further, as well as the potential for expanding this exciting area of research.

Finally, the last section in this chapter looks at what is required to develop a new paradigm of thought in progressing restoration ecology and the key recommendations for further research.

6.2 The state of restoration ecology

6.2.1 Rationale, context and importance

In the year of 2006, the world finally woke up to the issue of climate change and the realisation that it is an issue that is not going away and requires an international commitment to overcome. What people didn't realise was that ecological restoration might be the means to achieve this.

The release of a report by British Government Economist, Sir Nicholas Stern, in November 2006 served to quantify the economic realities of climate change and the pending consequences under a range of scenarios. The Stern report predicts a catastrophic cost of \$9 trillion if nothing is done to stop global warming (Stern 2007). The report calls for a concerted international effort to cut greenhouse gases or face economic failure worse than the Great Depression. It has also precipitated a more aggressive response from governments around the world; in New Zealand this includes the development of three policy discussion documents on energy security, as well as a national commitment in 2007 by the Prime Minister to sustainability, and greater cross-party agreement on methods to address climate change.

As the Stern Report ignited governmental attention, Former US Presidential candidate Al Gore released the movie *An Inconvenient Truth* in November 2006, which served to bring the science and future implications of climate change into the minds of individuals through mainstream media. Gore's compelling movie has transformed an academic topic into something that everyone can understand and as a consequence, mainstream media has taken the issue on – in New Zealand, environmental articles and programmes now feature regularly in the national newspaper or on the local television network. The level of public interest has escalated such that even more conservative media, such as the National Business Review and the Independent Financial Review have succumbed to publish articles on the topic.

If it wasn't enough for climate change sceptics to accept the realities presented in Gore's movie and Stern's report, on the 2 February 2007 the first section of the four-part International Panel on Climate Change (IPCC) Fourth Assessment report was released. With more than 2,500 scientific experts and over 800 contributing authors from 130 countries, compiling six years work, *Climate Change 2007: The Physical Science Basis* - the first part of the IPCC report – concludes that human activities are unquestionably responsible for the marked increase in atmospheric concentrations of greenhouse gases, with carbon dioxide and methane levels far exceeding pre-industrial values going back 650,000 years (Solomon et al. 2007).

Few can debate now that the human species is inextricably linked to the global environmental issues that are becoming more apparent and alarming. Increasingly, there is greater focus on what to do next – adaptation and mitigation methods. The world is aware that greenhouse gas emissions are a

catalyst and these have become a key focus of methods for adaptation and mitigation. Reducing carbon emissions is of particular concern as it is linked to activities that affect most developed countries (energy and transport) and can therefore be influenced by a large part of world's population using these services.

Apart from the media regularly providing information on how to live more sustainably on a 'low carb (carbon) diet', and the likes of Al Gore's 'seven-point pledge', urging people to make an individual commitment to combat climate change (see www.algore.com), the growth of carbon as an internationally tradable commodity is one of the more fascinating developments, and perhaps what may be most influential in directing resources into ecological restoration projects in the future.

In January 2005 the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) commenced operation as the largest multi-country, multi-sector Greenhouse Gas emission trading scheme world-wide. The EU ETS was set up as a key tool in enabling the EU to achieve its Kyoto Protocol target of 8% below 1990 levels. Phase I of the Scheme will run until 31 December 2007 and Phase II will run from 2008-2012 to coincide with the first Kyoto Protocol commitment period. Phase I has enabled caps to be set on different sectors' 'Business As Usual' emissions so that in Phase II, surpluses or deficits above or below these caps can be traded on the EU market.

Similar markets are beginning to emerge elsewhere. In New Zealand, the national Stock Exchange (NZX) has committed to launch a carbon trading platform (Time Zone One – TZ1) in 2008 for the exchange of voluntary (or grey-market) carbon credits and compliance (Kyoto) credits across Australasia. As the New Zealand Government warms to setting caps on industry emitters, this market has the potential to become quite lucrative. New Zealand businesses are already aware of the potential benefits, and costs, of such a scheme and there has been a sudden trend towards becoming 'carbon neutral' and 'sustainable'. For example, Meridian Energy, a supplier of 100% renewable energy, announced that they are certified carbon neutral in 2007. As a generator and supplier of energy, it makes sense that this company provides a proactive approach to offsetting emissions. Similarly, Grove Mill, a New Zealand wine producer who's profits largely depend on the capacity to export product like any other, has already become carbon neutral. This is perhaps in quick response to the 'food miles' stigma that has stung many New Zealand exporters by pressure from international customers such as Marks & Spencer, Sainsbury, Tesco, and Wal-Mart. Inevitably, becoming carbon neutral has meant that Grove Mill is now accessing the Tesco market and Sainsbury has doubled its order (Anne Smith pers comm. 2007).

But what does becoming carbon neutral mean? It is generally understood as a three-step process: measure emissions, reduce emissions, and offset the remainder. In New Zealand, a company called 'carboNZero', established by crown research institute Landcare Research, has been set up to take businesses through this process and to provide a mechanism for Kyoto-compliant offsets. The EBEX21 scheme (another Landcare Research initiative) provides the offsets, using ecological

assumptions to determine the quantities of land required to be covenanted and afforested in order to offset a specific level of carbon emissions.

In the wake of the EBEX21, and similar international forest offset schemes such as the UK Future Forests, afforestation is quickly becoming well-accepted and sort-after as a means for offsetting emissions and purchasing carbon credits. While investing in renewable technologies to offset emissions is still in its infancy and afforestation poses a mutual win-win on both carbon and biodiversity, the need to ensure the integrity of science behind afforestation credits becomes increasingly important as global carbon trading markets gain momentum.

If ecological restoration is going to become one of the dominant means by which to facilitate afforestation then we need to be sure that we understand how to manage the process as effectively as possible. This thesis has attempted to illustrate the theoretical and practical obstacles currently experienced in ecological restoration and to identify the areas where research may serve to advance from these challenges.

This thesis expounds that restoration is a social process as much as an ecological one – moreover that the success of ecological outcomes is dependent on understanding and managing the complexity of social layers involved. As discussed in previous chapters, these include: understanding the innate connection between people and nature and how this can be channelled into restoration action (Chapter 1); establishing governance and responsibility for restoration and consistency in method (Chapters 2 & 4); ensuring that practitioners can understand and interpret restoration science (Chapter 3), and; scientifically quantifying the role of people as active ecological participants in the restoration process (Chapter 5).

Research undertaken within these areas may facilitate a more organised and realistic approach to restoration, providing a more robust mechanism for channelling carbon offset projects in future.

6.2.2 Restoration realities today: theory, guidance, plans

The central discrepancy between what is desired and what is done in restoration is an issue of idealism versus realism. The use of ecological theory as a foundation to underpin restoration science is not necessarily a mistake, however it may have served to precipitate an impossible expectation of what is achievable in restoration. This thesis has shown that ecological theory is not a fair benchmark due to the complexity of social parameters that exist in restoration.

Needless to say, it is not helpful that ecology alone is plagued by its own issues of reliability as a science – Chapter 3 discussed the fact that few theories in ecology are consensually established (Sagoff 1988; Peters 1991; Botkin 2000) and that it is a science consisting mainly of hypotheses,

models, case studies, and “rules-of-thumb” (Shrader-Frechette & McCoy 1993, 1994; Shrader-Frechette 1995).

In many respects, the issues clouding the rigour of ecology have simply been transferred to restoration science, for example – the numerous terminologies available to explain a given phenomena; the range of definitions proposed for a single terminology; the variety of models developed to describe a given process, and; the diversity field techniques available for a specific line of enquiry.

Furthermore, the ideals of restoration – for example, ‘like-for-like’ reproduction of past ecosystems - are in conflict with the realities of what is achievable in today’s human-dominated landscapes. The awkwardness of fitting an old ecological jigsaw piece into a new socio-ecological puzzle has raised numerous questions. Do we reinstate an historical structure or is an ecosystem that functions within the landscape context more important? What needs to be restored and what constitutes restoration – does it depend on who is footing the bill and setting the goals? At what temporal and spatial scale do we measure the success of restoration projects? If the ‘reference’ ecosystem is continually evolving, is it even feasible to set goals for an ‘end-point’ set of conditions in restoration projects? Can humans even effectively assist the recovery of a desired ecosystem?

Given the above, it is no surprise then that the restoration guides reviewed in Chapter 2 show no consistency in the use of language, approach, or methods for planning, implementing or evaluating ecological restoration. All neglect to bridge the most important gap in restoration science – integrating social and ecological dimensions as an inclusive framework.

With poor guidance available for practitioners, the development of suitable restoration plans is difficult. This was demonstrated in the review of restoration plans in Chapter 2, where it was observed that there is large variability in the goals, methods, structure and language used between plans. Apart from a neglect in sound scientific guidance, the variability in restoration plans also appears to be affected by social elements. Multiple stakeholders with a variety of motivations influence the level of resources, skills and time available for restoration, as well as the resulting end-point system. In addition, there is a difference in the technical language used in guides versus that in practitioners’ plans – ecological concepts tend to be described academically in guides versus colloquially in plans.

While Odum’s (1969) model of *Trends to be Expected in the Development of Ecosystems* may appear to provide some stable theoretical guidance on behalf of ecology, even verifiable by others (Ohtonen 1994; Christensen 1994; 1995; Magaeu et al. 1998; Callicott et al. 1999; Ohtonen et al. 1999; Aikio et al. 2000; Knops & Tilman 2000; Wilhelm & Bruggemann 2000), it fails to accommodate the social technicality of people actually being involved in restoration. This includes the governance, resource and jargon issues as described previously, but also the physical presence of people interacting as trophic participants in the restoring ecosystem, as presented in Chapter 5. Modifying Odum’s (1969)

model to be realistically applicable to the restoration context would need to incorporate these critical social factors.

6.2.3 Restoration realities today: practitioners' perspectives

These observations are consistent with the perspectives of practitioners involved in restoration. In Chapter 4 focus groups were undertaken, consisting of New Zealand restoration practitioners from three major sectors (community, public, and private) in order to investigate their opinion on current trends in New Zealand ecological restoration and the feasibility of applying Odum's (1969) model in practice.

Before even beginning to discuss Odum's model with the practitioners, it became apparent that social constraints are a major hindrance at the outset to restoration practice in New Zealand. Practitioners feel that as the economic benefits of restoration remain formally un-quantified (e.g. value of restoring ecological services; long-term conservation value; value of engaging and educating community), there is no business case to prompt government to invest financially, nor legislatively. Abensperg-Traun et al. (2004) illustrate how different political frameworks and priorities can impact upon the funding and success of ecological restoration. Drawing back to section 6.2.1, the realisation of a market value of carbon may serve to elevate restoration as a priority for funding and supporting policy led by government, since restoration will facilitate a quantifiable carbon 'credit'.

In the mean time, while there is no specific policy around restoration in New Zealand, no-one is specifically responsible for taking charge of it. Those that do get involved have their reasons – public sector (crown research institutes, regional and local authorities) generally undertake restoration in the context of conservation under the New Zealand Resource Management Act (1991); community restoration groups tend emerge from passionate individuals concerned about local conservation, and; and the private sector (consultancies, landscape architects) reap an economic benefit as contractors on behalf of organisations obliged to undertake restoration as partial fulfilment of a resource consent under the Resource Management Act (1991).

With no formal regulation, a diverse array of players (and motivations) involved, and an eclectic mix of theoretical guidance available, it is no surprise that ecological restoration in New Zealand is undertaken in an ad hoc manner with varying degrees of success. This is exacerbated by the lack of resources available to support restoration, as well as the different levels of expertise involved in projects.

Other social constraints that have hindered the overall progression of restoration as a science include the issue of practitioners unwilling to share methods and information relating to a particular restoration – that this information is considered to be the intellectual property of the project owner. In addition, practitioners indicate that because there is no regulation on how projects are managed, the restoration

data collected by the different sectors involved may be unreliable or inapplicable due to the varying motivations/influencers of project outcomes. This draws upon the final social issue – human perception, where the aesthetic concepts of the ‘ecology’ to be restored are perceived to lie in the pockets of those who are commissioning the project.

Considering the application of Odum’s model to the restoration context in the wake of these complex social layers, practitioners identify a number of issues; Odum’s model is too complicated, time consuming and academic, and inadequately captures the social realities of restoration practice, including accommodating the actions and effects of human involvement in restoring ecosystems.

In this sense, from the studies in Chapter’s 2 and 4, Odum’s model really serves to exemplify the discrepancy between idealism and realism that presently divides the theory and practice of restoration.

Some attempts have been made to bridge this gap, to incorporate some of the complex social issues within a traditional ecological decision-making context. McDonald et al. (2001) developed a socio-economic-ecological simulation model, SEELAND, to simulate the feasibility and ecological consequences of land acquisition for the purposes of establishing and expanding protected wildlife areas. The model consists of three components: sociological (landowners’ attitudes towards selling their land); economic (e.g. fair market value and incentives); and ecological (land-cover types, parcel sizes and locations). They applied the model to an area (3035ha) of (mainly) privately owned land adjacent to the Shiawassee National Wildlife refuge in Michigan (USA). Applying the model they found that most of the (ecologically) high-priority land was not available for purchase as landowners’ attitudes towards selling their land significantly affected the amounts and types of land purchased. The use of incentives was also necessary to facilitate greater acquisition of land.

Ruliffson et al. (2003) add a new dimension to the decision-making process of open space protection; site accessibility. Their model was designed to help planners allocate funding for open space protection among eligible natural areas with the twin objectives of maximising public access and species representation. Applied to 68 sites across Chicago, USA, the model found that increasing required species representation reduces the maximum number of towns with access to reserves, and the trade-off between species representation and site accessibility increases as the budget is reduced. The inclusion of site accessibility affects optimal reserve design and this adds a new dimension to reserve site selection.

Luz’s (2000) study demonstrates that greater public consultation and participation in landscape planning projects speeds up the progress of their implementation. Research undertaken in southern Germany involved establishing measures to improve communication between scientists, planners, administrators and local stakeholders using round tables, workshops, and information campaigns. It was found that these measures serve to accelerate implementation, suggesting that landscape

ecology can be holistic only if public awareness and participation play an equal role with the expert views of natural scientists and planners.

These examples show that by incorporating some of the social realities within an idealistic ecological framework, there is greater potential for synergistic and achievable, win-win outcomes.

6.3 Restoration – a fusion of humanity and ecology

Taking this a step further, this thesis has attempted to show that not only are the political, economic, cultural, and emotional social factors relevant and influential in shaping ecological outcomes, but also that by actively managing an ecosystem humans inevitably become an additional ‘species’; their actions having tangible ecological effects.

It is necessary that this critical social dimension is investigated in order to fully come to grips with the effects of restoration activities and how best to advance this increasingly important area of science and practice.

Chapter 5 begins to establish an appreciation of the general activities initiated by people in ecological restoration and attempts to qualify these in terms of their ecological effect and subsequently, what this means in regards to the basic ecological roles of humans in restoration.

The actions that people undertake in restoration have a range of ecological consequences on the subject ecosystem. While one may like to think that restoration is a positive human-environment relationship, this may not be the case. For the purpose of this thesis however, the debate is irrelevant since what matters is that a relationship exists nonetheless. Actions such as establishing or removing vegetation, and introducing or removing fauna and organic matter, all bear ecological consequences. Some of these include: increasing species diversity; altering spatial structure and size; facilitating nutrient fixation; increasing biomass, and; altering interspecific competition. Burke and Mitchell (2007) qualify these effects as specific ecological roles and determine the range of trophic functions that humans serve in their involvement in restoration. None of these roles or effects are recognised in ecological succession models such as Odum's (1969), thereby making it difficult to apply such ecological models directly to the restoration context. However, Chapter 5 presents a range of evidence supporting the fact that the ecological effects of the human-ecosystem restoration interaction, as presented by Burke & Mitchell (2007), do indeed exist. Therefore, there is a good possibility that expanding on their research will serve to provide a more realistic appreciation of how ecosystems develop in the presence of human involvement.

This area of ecological research makes for a very unique, but perhaps growing area of exciting scientific investigation. Understanding that human participation has to become part of the scientific

work, rather than seen to be undermining the power of science, introduces a new paradigm for progressing research.

Some have already begun to realise this concept. Purdon (2003) investigates how this applies in the context of ecosystem management for the purpose of Sustainable Forest Management (SFM). He argues that ecosystem management overlooks the paradox inherent in the concept of 'Nature', limiting the scope of the SFM debate by maintaining a binary opposition between Nature and Society, humans and environment. Purdon argues that Nature is paradoxical because humans are a part of Nature, by theory of evolution, while at the same time Nature is a social construct created by humans, and thus artificial. He proposes that at the metaphysical level, a different role for ecologists and forest managers in public participation procedures needs to transpire so that at the socio-political level, SFM will necessitate improved transparency and participation forestry, criteria that can be obtained through community-based ecosystem management.

In light of global trends towards sustainability, Cabezas et al. (2005) develop a statistical model using Fisher Information in an attempt to quantitatively link measures of ecosystem function to sustaining the structure and operation of the associated social system, and vice versa. Their model, consisting of 5-trophic levels, 12-compartment (species) food webs and an associated basic social system for the population of omnivores at the top of the food chain (humans), demonstrates the opportunity for new research in this area of human-ecosystem sustainability and the potential this has to be applied under a range of given social and environmental scenarios.

6.4 From theory to practice – a new paradigm for progression

One of the critical points made by practitioners in the focus group research in Chapter 5 was that the success of restoration is in the end, hinged upon the commitment of people to the project. Funding and resources are important, but if the project lacks a stronghold of committed people then it is less likely to meet long-term ecological goals. This is quite ironic really, to suggest that ecology requires society in order to regain function. Perhaps it is not the case, since, given sufficient time, almost any degraded or destroyed ecosystem will restore itself (Bradshaw 1987). However, the rapid rate at which humans can destroy an ecosystem, versus the long timeframe an ecosystem requires to recover stability and function independently is the reason why restoration exists. Therefore, going forward into the future, leaving systems to self-restore may not be the wisest approach to human-ecosystem sustainability.

This is not to suggest that restoration efforts need to 'get it right the first time'. As identified throughout this thesis, there is enough variability in the theory and practice of ecology and restoration to suggest that outcomes are not deterministic, and no right or wrong way exists. Ecology is not a hard science like physics or mathematics. It is a malleable science, full of testable 'assumptions' rather than 'rules'. We can further our knowledge, and generate more questions through this process of testing, but people are required to make this happen.

Given that people are such a fundamental part of progressing restoration ecology, both the practice and the science, two simultaneous arms of research are recommended from the findings of this thesis. These should involve:

- I. Understanding the social drivers of restoration and how they connect to action, and;
- II. Understanding how restoration activities led by humans affect ecology.

Philosophy driving restoration participation

Like anything, it is impossible to make somebody like or do anything. The age old saying 'you can lead a horse to water but you cannot make it drink' applies to many aspects of life – meaning that one needs to feel personally compelled to do something before they can act. Kevin Roberts' famous book *Lovemarks, the future beyond brands*, was published in 2000 in response to the growing awareness by marketers that consumers are no longer drawn to products that are irreplaceable, but rather those that are irresistible. The book has since caused a paradigm shift in the way companies across the world market their brands and products. They seek to engage individuals on an emotional level, touching heart and mind.

This approach can be applied in the context of restoration as well. In the basic sense, restoration needs to be meaningful to the individual to compel them to participate. But how can we make it meaningful to everyone?

This thesis has touched on a range of ways in which this might be possible. If further research (or market drivers) begin to economically quantify the environmental *and* social benefits of restoration then this provides a meaningful currency for the restoration business case, enabling policy makers, land developers and conservationists to weigh up their decisions more meaningfully.

By promoting restoration to the public as a necessity for preserving current human lifestyles, as suggested by Miyawaki (1998), will people be more motivated to participate in restoration if it means they can continue to exploit a particular resource (Coen & Luckenbach 2000)? Promoting this 'enlightened self-interest' (Cairns, 2003) approach might work but research suggests that it is more likely people will engage in restoration if they are part of the decision-making process, a part of developing sustainable human-ecosystem outcomes (Cairns 2000; Hackney 2000).

Perhaps we need to tap into the more innate connection that exists between people and nature to fully realise how to make restoration meaningful to the individual. The vast amount of research presented in Chapter 1 by Wilson (1984) and many others suggests that this could be a powerful way to engage people in restoration. Could restoration be promoted in the context of improving human health and wellbeing, as 'eco-societal restoration' (Cairns 2003)? Certainly after the deadly heatwave that killed nearly 15,000 Parisians in 2003, greening urban infrastructure by planting trees on and around buildings has been a priority for reducing the effects of heat inside buildings and preserving lives (Salagnac 2007).

Fundamentally, people need to understand initially that they *are* part of the natural world – that there is not a separate 'society' and 'nature' as such, but rather that they are part of an interchanging, dynamic, single system (Naveh 1998; Kendle & Rose 2000). Education may be a key part of this – both the provision of 'nature encounter' opportunities as well as improving ecological literacy through training in schools or other learning institutes. This may serve to empower people with a conceptual understanding of the value of ecosystems and through felt experience, develop an emotional attachment to specific natural areas (Orr 1992; Pyle 2003).

Above all, if human commitment is paramount to the success of restoration projects then the language that is used to engage and educate them must be simple, realistic and meaningful. The theory, guides, plans, and practitioners surveyed in this thesis all point to this very important aspect – complex methods and information do not reflect the realities of restoration practice and therefore do not work. This is not a new revelation – an interesting attempt by Schaefer (2006) to develop a more meaningful way to describe ecological restoration to the public proposes using the healing of the human body as an analogous model for ecological restoration.

There are many avenues for potential research in this area of understanding what motivates people to care and participate. If further research can understand the 'lovemarks' of restoration, then there is a real opportunity to engage the group that we depend most upon for the success of our projects – people.

People as plain members and citizens of the land

Once we understand what drives restoration action, it then remains to appreciate how action affects ecology. This thesis proposes that the second arm of research that requires further development in order to progress restoration ecology is quantifying the ecological effects of human interaction with nature during the process of restoration.

This initially requires a holistic land ethic that views people as a species within the global biosphere – or, as Leopold proposed in 1968 - as plain member and citizen of the land. This applies to understanding not only that restoration management requires a holistic human-ecosystem view, but also a holistic human-human approach to management; integrating multiple stakeholder ownership of restoration. Many (Bradshaw & Bekoff 2000; Luz 2000; Robertson & Hull, 2003) have already presented research to support the importance of the latter.

Investigating the role people as ecological participants in ecological restoration requires a completely new paradigm shift in the present approach to restoration ecology. If we can accept that as humans we are part of nature, then investigating our ecological role and influence in respect to all other biotic and abiotic components is not such a far-fetched idea. As such, restoration ecology can still remain a science if 'ecology' means people as well. Investigation along this line of enquiry will enable the development of realistic, rather than idealistic body of ecological theory, providing a stronger foundation consistent with the principles of restoration.

6.5 Conclusions & recommendations

Albert Einstein once said ‘problems cannot be solved at the same level of awareness that created them’. This thesis has uncovered a number of problems with the existing approach to restoration ecology including: a lack of sound theoretical guidance; ad hoc methods for planning and implementing restoration; no real appreciation of the human-ecosystem relationship, leading to a lack of accountability or responsibility for restoration, and also a somewhat ignorant application of ecological theory to the restoration context.

This thesis has attempted to create a new level of awareness, one that may be conducive to solving some of the problems above. Two major areas of research stemming from this study are recommended for enabling significant progress in restoration ecology:

- I. Understanding the social drivers of restoration and how they connect to action, and;
- II. Understanding how restoration activities led by humans affect ecology.

As people are the principle component of restoration, overcoming the emotional and technical barriers to their participation is the key to facilitating greater public engagement.

Restoration will increasingly become a critical part of a sustainable existence for the human species on this planet in future. Delivering efficient and effective restoration will be necessary and this thesis has tried to show that it is possible if a new paradigm begins to be adopted. We changed our minds on climate change in 2006; let’s revisit our approach to restoration ecology today.

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Appendix 1 – Participant Information Sheet and Consent Form.



PARTICIPANT INFORMATION SHEET FOR FOCUS GROUP PARTICIPANTS FROM THE COMMUNITY SECTOR

School of Geography and Environmental
Science
The University of Auckland
Private Bag 92019
Auckland
New Zealand

Title: Identifying a New Way Forward for Ecological Restoration

To: Subject

My name is Sarah Burke. I am a student at The University of Auckland enrolled for a Doctor of Philosophy Degree in the School of Geography and Environmental Science. I am conducting this research for the purpose of my thesis on Ecological Restoration and have chosen this field because I believe there is much room for improvement in the way Ecological Restoration is approached. I have been funded to undertake this research by the New Zealand Federation of Graduate Women.

You are invited to participate in my research and I would appreciate any assistance you can offer me. As part of my thesis I am conducting focus groups with expert ecological restoration practitioners from three key sectors involved (private, public, community). I have developed a new approach to ecological restoration that may be of interest to you, as an expert ecological restoration practitioner from the community sector, and would like to gather your thoughts and feedback regarding how useful and feasible this approach is to the work that you do.

I would like to invite you to be a part of the community sector focus group, however, you are under no obligation at all to be involved. **Two focus group meetings** are proposed and your group will include up to five people. Focus groups would take about two hours and would occur after normal work hours (e.g. 6-8pm) in Auckland. I would prefer to audio tape the interview but this would only be done with your consent. Unfortunately you will not be able to edit transcripts or withdraw information from of the audio tape recordings due to the potential for a breach of confidentiality of information gathered during a group discussion. Following the focus group meetings, you will be offered a written summary of the results that will not disclose the identity of any individual participant or any specific individual comments made during focus group meetings.

If you do wish to be part of the focus group, please let me know by filling in a Consent Form and sending it to me or phoning me on Tel: 021 154 3685 after hours. All information you provide in the focus group is anonymous and your name will not be used.

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more please phone me at home at the number given above or write to me at:

School of Geography and Environmental Science
The University of Auckland
Private Bag 92019
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My supervisor is : Dr. Neil Mitchell
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The Head of Department is: Dr. Willie Smith
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For any queries regarding ethical concerns please contact:

The Chair, The University of Auckland Human Participants Ethics Committee,

The University of Auckland, Research Office - Office of the Vice Chancellor, Private Bag 92019, Auckland. Tel. 373-7999 extn 87830

**APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE on for a period of
years, from Reference**



School of Geography and Environmental Science
The University of Auckland
Private Bag 92019
Auckland
New Zealand

CONSENT FORM

THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF SIX YEARS

Title: Identifying a New Way Forward for Ecological Restoration.

Researcher: Sarah Burke

I have been given and have understood an explanation of this research project. I have had an opportunity to ask questions and have them answered.

I understand that I will not be able to edit or withdraw information from transcripts of the focus group audio tape recordings due to the potential for a breach of confidentiality of information gathered during a group discussion.

- I agree to take part in this research.
- I agree/do not agree that the focus group meetings will be audio taped.

Signed:

Name:
(please print clearly)

Date:

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE

on for a period of years, from/...../..... Reference/.....

(This section is to be completed **after** advice of approval has been received from the UAHPEC, and **before** the sheet is given to prospective subjects)

Appendix 2 - Focus Group Responses by Theme

	COMMUNITY	PUBLIC	PRIVATE
Current trends in New Zealand ecological restoration (ERT)			
ERTINITIATE <i>How is restoration initiated/promoted within each sector in NZ? (Consider motivations: e.g. obligations under statutory regulations/polic/RMA; habitat/species protection; return regional heritage; educational purpose; funding available).</i>	<ul style="list-style-type: none"> There is a reasonable amount of funding available from local and regional authorities that community groups can apply for but not much available in the way of voluntary help from these groups to support getting something underway immediately. There are also various grant bodies available to fund community restoration projects e.g. Biodiversity Condition Fund and Biodiversity Advice Fund. The triggers for stimulating commitment from different kinds of communities to restoration are different e.g. Asian communities getting involved because they think it is the right thing to do as a 'kiwi'; farmers forming their own group; other communities do it because they think they are reconnecting the land and can bring back tuis etc. Maori people may have lost knowledge on how to take the first step in reconnecting land to provide resources for sustainable harvesting and at the same time, the triggers for getting Maori commitment to restoration have not been fully investigated e.g. restoration could be considered as a part of tribal wellbeing restoration. 	<ul style="list-style-type: none"> ER is policy directed – no policies for restoration then little resources available for restoration. New MfE strategy and amendments to the RMA (introducing the word biodiversity 1.5 years ago) mean that councils are more obliged to set policy for restoration. There is some confusion over the roles of RA's and TA's in restoration - are regional authorities responsible for setting restoration policy and territorial authorities are responsible for implementation? Restoration strategy needs to be linked in with other strategies e.g. pest and weed. Restoration is usually framed as biodiversity or conservation – it does not stand alone. Auckland and Wellington Regional Councils have funding available for landowners and community groups to restore and also have programmes for restoration on the land they own. Other councils in New Zealand do not have the legislation to own land and so only have funding available for landowners and community groups. Research on restoration funded through commercial contracts. Restoration can also be initiated as a part of a consent e.g. coal mine. Restoration (under natural heritage) competes with transport for funding from the same pot. Benefits of getting a train are immediate. Benefits of restoring biodiversity are 10-20 years down the track. DOC research shows that it is middle-class women who are often initiating and driving restorations. Management priorities determined by protecting and restoring 'outstanding natural landscapes and features'. 	<ul style="list-style-type: none"> Restoration projects initiated by contracts through resource consents (for mitigation), or from private landholders, or council/Doc management plans/landscape planning or amenity. There are no set methods for private co.s doing restoration. Some will follow through with maintenance for 3 years, others only do contract design and contract management, others will be involved from through all stages – plan design, implementation, monitoring and maintenance. Private sector's techniques for restoration are own IP.

<p>ERTGUIDELINES</p> <p><i>Are there any universal/standard protocol or guidelines used by practitioners implementing restoration projects in NZ?</i></p>	<ul style="list-style-type: none"> FORMAK – although it is very sophisticated and you need to practice it to get the hang of it. You also need the specialist skills for doing the monitoring and knowing how to id plant and bird species. If you don't have these skills you can't use FORMAK. 	<ul style="list-style-type: none"> FORMAK – but it is quite complicated and users require initial training. The quality assurance of data entered by users is unknown. Councils have there own set criteria for types of plants to plant in restoration. Unfortunately this can lead to problems e.g. trees planted in wetlands, inappropriate planting densities, reduction in restoration of other (non-tree) habitats e.g. grasslands for lizards. Restoration approaches still focused on structural end-points, rather than kick-starting processes. Wai Care provides some guidance on restoration. 	<ul style="list-style-type: none"> Consent contracts require plants to be eco-sourced. FORMAK but it is not getting used widely. Use own methods (IP) for developing restoration plans (x3) Some online information on restoration available e.g. Environment Waikato. Also Landcare Research, NZ Landcare Trust and NIWA. Council guidelines on restoration plantings useful but usually use them as a reference point along with learnings from own project work (x2) Existing approaches to restoration ecology are about mitigation or prettying an area up, getting a rubber stamp from the council – ecology is not seen as infrastructure that is part of the built environment. Guidance for restoration may be very different if it were to be considered in this way. Restorations are very site specific (variations in microclimate, species attributes). There can be problems encountered when using generalized restoration guidance from e.g. council. Individual site plans have to be done.
<p>ERTPROCESS</p> <p><i>What is the typical process (by sector) for undertaking a restoration project? What are the limitations/obstacles that can be encountered?</i></p>	<ul style="list-style-type: none"> Community practitioners are really keen to understand more about the scientific side of restoration (evidenced in turnout of community practitioners to e.g. Landcare Research ER seminars). The \$\$ value of restoration is not fully accounted for e.g. if you spend X amount on restoration in an urban area, you are committing to spending more on that are in future for pest management etc. The same amount of money could have achieved a lot more doing pest control n an area well established e.g. waitakeres. But how do you put a dollar value on changing someone's attitude to 	<ul style="list-style-type: none"> Types of restoration can be limited/complicated by the groups involved e.g. Transit planting wildflowers on traffic verges, council's petitioning to plant natives, communities desire to have wild flowers. Funding source can also complicate the methods used for restoration. E.g. restoration funded by Infrastructure Auckland is tied to the performance of the number of trees put in the ground – not on the plant community that is established, or non ecological goals/outcomes such as human community understanding and awareness. Measures of success are mechanical. Often times councils and e.g. Transit follow a formalized model for restoration plantings but this is not always appropriate (e.g. planting set no. plants/ha; removal of plants/trees, planting specific species). There are still problems with terminologies that 	<ul style="list-style-type: none"> When natural processes take over, often in times they can completely change the composition of species that were put in the ground – or what one might expect to see after that time. Much of the restoration taking place is on farm landscapes. We don't see the project past the design stage. We go back every month to do maintenance and photopoint monitoring. Also can include some fauna monitoring, insects, fisheries, vegetation plots – depends on the client's requirements. We do not usually try linking data from different projects as they are all quite site specific. When tendering for projects, the first thing to go out the window is photopoint monitoring and intensive monitoring

	<p>the environment or educating people.</p>	<p>are affecting whether restoration takes place, how it takes place and what it is classified under e.g. biodiversity or conservation or protection or landscape management. Restoration applied to historical cultural resources means something quite different from restoration applied to historical ecological communities.</p> <ul style="list-style-type: none"> • There is not any 'management of natural areas' that is left in NZ. All work involves restoration and so should be understood that way. This approach wouldn't work though in terms of setting priorities. • Restoration mandate for management only (i.e. no research) means that projects cannot be used as experiments, and potentially monitoring data may not be used for any purpose. • Restoration for carbon fixing does not ensure the biodiversity value of the community that is restored. • The present classification of areas of high conservation value does not take into account the potential impact that restoration could have on the value of that area in say 20 years. E.g. Tiritiri was not classified as an area of high conservation value 30 years ago. • Restoration (under natural heritage) competes with transport for funding from the same pot. Benefits of getting a train are immediate. Benefits of restoring biodiversity are 10-20 years down the track and are difficult to quantify in \$\$ terms. • Councils can't put more money into restoration research and monitoring than restoration management at present. • Research is undertaken when there is money invested into it or if there is a particular rare threatened species at stake, or of it is a requirement for bond release. • Covenanted land is not being monitored regularly to ensure that patches of bush have been retired from e.g. stock or other degradation. 	<p>because they are too costly.</p> <ul style="list-style-type: none"> • Ecological restoration projects require maintenance beyond the initial pilot stage to ensure they don't get infested with weeds etc. • Combining human/ecological needs from restoration can be difficult. E.g. restoration that fits in with the contextual landscape (ecologically and aesthetically); restoration that does not block site lines yet provides the right kind of stabilization to the soil or provision of habitat/resources for birds. • There are conflicting ideas about the use of exotics in restoration – there are pros and cons of using them. • Restoration jobs are limited by time and money – so this influences what ecological goals can be achieved. It also means that a lot of energy gets put into determining the lowest possible per hectare unit rate for getting the plant from seed to ground and maintained as efficiently as possible. • The timeframe after which a consent gets signed off (e.g. 5-10 years) may be too short for the ecological goals to be achieved in the restoration. • Ecological restoration is really just a metaphor – we are still designing landscapes (like in landscape architecture) except that we are expanding our understanding of how we as human beings relate to the landscape and therefore how we can develop the landscape in such a way that it meets our own needs but succeeds ecologically as well. • Restoration plans are for both structure and function, tying in plantings with requirements of fauna. • One of the biggest problems associated with eco-sourcing is getting the stock grown in time for the restoration timeframe. Wetland species are particularly hard to get hold of as few nurseries are propagating them. • Research on what is happening to all our
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			<p>restoration projects 5-10-20 years down the track is lacking due to insufficient resources. That's where we have a real paucity of information.</p> <ul style="list-style-type: none"> • Sometimes you need to go out of your ecological district to get species for restoration – this can compromise the integrity of your ecotypes. • Baseline data is lacking from many restoration projects – so many people start monitoring after plantings/management has taken place.
<p>ERTINTEGRATE</p> <p><i>Is there any integration/communication between sectors to feed back results/experiences? Who would be interested in this information?</i></p>	<ul style="list-style-type: none"> • Increasingly there are more projects underway that integrate practitioners from all sectors e.g. Waiatarua – council contracts privately to do the restoration work, community uses the site as a recreational/education opportunity, university does annual research trips to the site. • Restoration in catchments by necessity needs to involve a wide range of groups as well. • Twin Streams is another restoration project that is getting underway involving community, council, Landcare research, local iwi and even the business sector. • Scientists' view of amateurs recording information is very suspicious. • A lot of Landcare Research Scientists are good at working with the community. • Practitioners don't collect the information that scientists want. • Some parts of the country e.g. Christchurch they are promoting the connection between scientists and practitioners really well. Others e.g. Auckland it is less often the case. • Scientists line of enquiry may be too specific for community 	<ul style="list-style-type: none"> • Restoration ecology is a sub-discipline of its own. It is not interrelated with applied ecology. • RE still very young discipline and will take some time to pick up speed with regards to using practical ER as experiments (for testing ecological theory). • Within the public sector, there is very little co-ordination in approaches to restoration or sharing of results/information. • Within councils, restoration isn't a great focus – not a great deal of policy around restoration and therefore no real need to form strong links with e.g. DoC and Landcare Research. • Departmental compartmentalization within councils means that there can be different approaches to restoration-related activities e.g. catchment people planting willows, biodiversity people pulling them out. And these departments don't talk a great deal to one another. • Community restoration data is not useful for high quality data on specific research questions because there is no guarantee of quality assurance of data, how its been collected etc. This data may be useful for gross indications of long-term changes in restored ecosystems. • Councils are being almost mobbed by community groups who want to find out how they can monitor their projects and measure their progress. • DoC are supposed to work outside their estate but they've only got resources to work inside their estate. • No integration between theorists and practitioners because theory doesn't recognize people and the economic reality of doing stuff 	<ul style="list-style-type: none"> • There is an increasing need for restoration practitioners to work more with one another – share ideas etc – but also to work more with ecologists. Restoration Ecologists could also benefit from the practitioners experiences that are as vital for restoration as the theory e.g. bag sizes for plants etc. • It is important that Landscape architects have ecology knowledge from the field so that the restoration plans that are designed will be more likely to succeed. • There is as much integration and communication as you are prepared to initiate. It is important to communicate and listen to what others are doing in the field as you can learn a great deal. It is a good sharing environment at the moment if you're willing to make the effort. • I open my projects up to people like NIWA and Landcare Research but they even lack the funding to carry out the research. • Integration between sectors occurs as a function of joint projects/contracts that get established. Outside of that, there is no pro-active sharing of information between sectors, although there are a lot of opportunities to do so, especially in e.g. catchment management approaches. Maybe one of the reasons why there isn't so much knowledge integration is because restoration projects are often very piecemeal in size. • Practitioners have a crucial role in educating politicians about the big picture

	<p>groups to undertake (in terms of time, skills and resources to dedicate to the research/monitoring).</p> <ul style="list-style-type: none"> • Scientists should investigate aspects of restoration that are going to have real practical implications for practitioners. • Particularly for smaller community restoration groups, there is not enough linkage to learn from their experiences and pass that knowledge around. 	<p>on the ground.</p>	<p>of restoration. May help them to set up policy and funding around restoration that is consistent.</p> <ul style="list-style-type: none"> • Developers need to be part of this whole process of restoration. • Unless the restoration project impinges on DoC land, or if the site is of biological importance, DoC do not usually hear about the project or take an interest in it – they're underresourced to do that. • Opportunities for integration and information sharing are mainly at symposiums and conferences. • There is no simple rule book to restoration, which is why maybe few people share their work.
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Using an ecological model to guide and monitor restoration management (MOD)

<p>MODECOGOAL</p> <p><i>How relevant is ecological integrity to restoration goals within sector-specific projects? How is ecology incorporated into the planning stages of ecological restoration?</i></p>	<ul style="list-style-type: none"> • Connectivity is extremely important in the success of restoration projects. • Urban areas are more difficult to get self-regeneration happening on (with natives) because of the heavily modified soil seed banks and soil condition. • Studies in restoration ecology tend to focus on specific aspects, whereas practitioners are taking on whole ecosystems at once, so application of studies to the management context need to take this into account. • Ecological integrity is important to restoration but pure ecology doesn't take into account impact of people e.g. just walking through the bush can influence species, such as birds on Tiri. • Is eco-sourcing really a major concern in dense urban environments like central or east Auckland? Where are you going to find the seeds?? • Eco-sourcing seeds may only be of specific concern to certain 	<ul style="list-style-type: none"> • There is a growing sense and interest of the native trees in NZ – people are even getting into them as office plants. This increased awareness and knowledge helps to promote interest in things like ecological integrity in restoration plans. • Ecological integrity has become more important over the years as use of ecological language has evolved and shifted – in the 1970's forests used to be classified as bush or scrub – now forest types are distinguished – even to their genetic regional ecotypes. Similarly, forest loss became known as forest destruction, because you can't 'lose' forest. So shifts in language have shifted understanding and subsequently practice of restoration. • May not be useful to use ecosystem size as the decision-making unit for restoration priorities. Patches of all different sizes are useful to different types of species. Island biogeography a useful principle for ecological restoration. • Ecological restoration theory does not presently recognize the roles of people and the economic reality of doing stuff on the ground – that's why there is a separation between restoration ecology and ecological restoration. • Ecological goals are influenced by whether or not people are involved in the system. E.g. for a cycle-way, low-lying plants will be restored in that area to ensure there is visibility for cyclists. 	<ul style="list-style-type: none"> • Difficult to combine ecological integrity with aesthetics in designing restoration. • Some ecological restoration e.g. of eroding slopes, wetlands should be done with assumption of permanency – i.e. the landscapes are protected from degradation or manipulated change permanently. But many modern landscapes need to incorporate human use so restoration should be geared towards incorporating the wide landscape context, including human use, development and change. • Ecology and restoration needs to be seen as a whole part of a range of activities that are done to manage a landscape. Ecological considerations in restoration need to be taken into the context of the landscape. • In developing a restoration strategy, one needs to keep in mind that although their choice of species for community composition may be fine, the seeds may not be available for that species during the year the project is initiated – so the ecology of individual species needs to be understood when creating ecosystems. • You've got to look at the ecosystem as a whole, rather than as individual units. So connectivity, food source and habitat are
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	<p>species e.g. may not need to be concerned about eco-sourcing with coprosmas as they cross pollinate readily with other species around them.</p> <ul style="list-style-type: none"> Some exotic species provide a food source for native birds during winter months when there are few native nectar sources around. If ecological function is the biggest concern then is it ok to have such exotics around? Or if ecological purity is the major goal then these species will get wiped out. 	<p>If there were no cycle-ways, different (taller) plants would be restored.</p> <ul style="list-style-type: none"> Restorations can have a diversity of ecological goals. There are no rules about having to eradicate every pest and restore everything right down to soil bacteria. It's ok to do just one or two things as long as it is ecologically sensible and the ripple effects are acknowledged. Ecological goals need to be realistic and achievable. Ecological goals in restoration are being shaped by NZ'ers growing ecological literacy and understanding of ecological interrelationships – e.g. impact of pests and weeds on native veg; the importance of bringing having native flora for bringing back native fauna. If you want real ecological integrity in your project you need to develop some specific ecological lines of enquiry and get professionals to carry out the monitoring and evaluation. Goals and targets for restoration are often set for results e.g. reduce possums by XX, rather than outcomes e.g. increase birds by XX. May have to do with a lack of understanding the species biology but this impacts upon what is then defined as a success or failure. 	<p>the major priorities for restoration, regardless of whether its using eco-sourced/non-eco-sourced natives or exotics.</p> <ul style="list-style-type: none"> You've got to be focused on function as a goal really, rather than get too precious about particular species, especially restoration in urban areas where you have people with their exotic plantings. There are very few general ecological principles that you can apply broadly to every restoration project. Eco-sourcing is a very important component of restoration method. Restoration is also about providing ecological infrastructure (e.g. natural hydrology) as well as ecosystem services (e.g. water quality etc). Self-sustainability is an important requirement for restoration projects but it may not ever be achievable esp in urban situations. Often some form of continuous management is required e.g. pest control. Should restorations aim for late successional community compositions? Maintaining early successional communities may be of equal ecological importance. You need to get a representation of different ecosystems at different age structures. We're aiming to achieve the ecology of what it was like before humans were here but realistically we're really just halting the decline really because humans are involved. Connectivity is an extremely important consideration, as well as balancing interior/exterior space of patches. You need big picture, landscape scale thinking.
<p>MODECOPRAC</p> <p><i>What place does ecology and/or ecological models have in ecological restoration practice?</i></p>	<ul style="list-style-type: none"> Some community groups set out to restore mature phase forest with the understanding that just planting the trees will facilitate this, without necessarily taking into account the finer things that 	<ul style="list-style-type: none"> You can't choose one example of restoration and expect to replicate it. People need to know what they can expect to achieve and reference models are simply that – references. Much of restoration presently is about managing re-invasion – halting the decline. 	<ul style="list-style-type: none"> Designing ecosystems that incorporate 'edge' so as to help make the patches resilient to pests and buffer against patch shrinkage. The purist approach of only using natives is not always the best one. E.g.

	<p>have to happen e.g. litter, cycling of nutrients.</p> <ul style="list-style-type: none"> • Age structure is not given a great deal; of consideration in plantings – too many plantings are putting in species of the same age group. • It is difficult to be puristic about genetic eco-types given the lack of available seed sources, and it is not always certain that the plants you receive from nurseries are eco-sourced. 	<ul style="list-style-type: none"> • Bonds for restoration work done under consent should not be given back until it is clear that the restoration site can reasonably self-manage. • There seems to be a blind faith that reintroductions of species will succeed if pests are removed. • Councils need to provide technical ecological information to community groups on restoration. • Community groups need to understand basic ecological principles e.g. food web links before they rush out and do management as it can have some negative ripple effects if the wider ecological consequences are not taken into account. • Resource consents do not have requirements around system functionality – rather bond is often tied around no.s put in the ground of plant XX species, remove XX species. It makes it more easy for people to make their development fit the consent conditions, rather than have a restoration that is actually ecologically useful. • Your restoration priorities might be based on sound ecological principles but when it comes down to realities on the ground – the people side of it has been left out. It may end up that your priority one site doesn't get anything done to it because it is difficult to access. Whereas a priority 3 or 4 site might get work done on it because it is more accessible and has a contractor living nearby. • We are trying to speed up or short circuit the ecological process of succession in restoration, but is this conceivable in the very short timeframes that (esp consents) set up for restoration projects? • Restoration practices that are perhaps more ecologically appropriate (e.g. leaving dying trees to stand rather than removing them) may be limited by requirements of people (e.g. may be a potential safety hazard to humans to leave dying trees in situ). Also, leaving logs and leaves for nutrient cycling versus removing them because it looks better aesthetically. • Not all restoration is for the purpose of enable access to people. Ecological goals can be optimized in these situations. 	<p>blackbirds are usually the first birds to disperse coprosmas around.</p> <ul style="list-style-type: none"> • We are better able to understand the ecology of our restoration sites and landscapes with the improvement of and increase in the availability of technologies such as GIS. This technology also enables us to prioritize which landscapes need to be retired in perpetuity, which parts managed ect. • When you take seeds from trees you also need to consider food chains – i.e. leave some seeds on the trees for birds. • IN areas that need to be restored, any plantings are better than no plantings. Even if you've got an exotic tree there you're still providing s resource for fauna as well. • Restoration is not a natural process – it is an interventionalist and a human construct. We can learn about seed propagation, interaction between plants, planting densities and ecological processes and keep the big picture in mind including the social issues of restoration – labour, transport ect. But at the end of the day we are developing a new environment and we don't know whether it will work or not. • Best way to decide what to plant is to look at what is growing around the site and try and then try and plant that. • Understanding ecological processes e.g. trophic webs of your system will help you to determine your ecological indicators e.g. kereru, stream habitat quality. • Human use of the surrounding landscape can hinder or reduce the effects of restoring a small site e.g. stream restoration that then passes through 20km of industrial estate before hitting the sea. Need to start from the sea and work back up. • Ecological goals need to be realistic e.g. can't expect tui to come back into urban areas simply by providing artificial feeders,
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<p>MODODUM</p> <p><i>What are the potential advantages/disadvantages/challenges/constraints of using a model like Odum's as a reference for ecological restoration?</i></p>	<ul style="list-style-type: none"> • Time/money constraints limit practitioners doing in-depth monitoring or data collection on their restoration progress. • People generally don't have the skills to accurately perform the required field and analytical techniques that are needed to put this model into practice. • This model is not applicable to urban restoration because many of the food chains are absent. Using this model would be limited to sites that are starting from bare ground. Need a model that focuses on seral stages for urban context. • Realistically, if practitioners set about to monitor and measure there progress, it will only be of a few indicators, say 6 things – this entire suite in Odum's model is not feasible. 	<ul style="list-style-type: none"> • Odum's model is appropriate for restoration that is from bare ground, but many restoration projects already have some kind of vegetation structure in place from the beginning. • Model does not account for the social complications associated with restoration e.g. application for fencing forest remnant from stock on an historic archaeological site in conflict with historic places trust who think that fences have no place on archeological sites so stock are free to destroy the remnant. Or e.g. urban restoration project with a lot of commitment from a community group should have as much value as a forest remnant in the middle of nowhere. • Model doesn't account for human modified landscapes. • Odum's model is too generic – it is good because it just looks at parameters but falls down because it could be applied to Canada/US/or NZ – but these are very different restoration contexts. • Model is good in that it encourages the user to think about parameters other than just community dtructure (and planting trees). 	<ul style="list-style-type: none"> • Model does not account for fluxes that occur naturally (i.e. even in the absence of people). • Universities could use Odum's model at a research level. • A lot of Odum's attributes are coming from an historic analytical process, whereas what we are doing in restoration is futuristic – so once you've got into it there would be more questions that you would need to ask. • People are involved in the process of restoration intensively at the beginning – the model does not account for this. It also doesn't account for the transition between human intensive changes and changes that occur when nature starts to take over. • It's not just Odum's attributes that are changing through restoration, the geophysical environment changes as well e.g. stream geomorphology. • How would you incorporate the variety of different levels of involvement that people have in restoration?

		<ul style="list-style-type: none"> • Few restoration practitioners have the money/labour required to implement Odum's model. Universities may be interested in it but outside of that, few others. • Practitioners don't necessarily need to know all 24 ecosystem attributes – they might need one or two e.g. wood pigeon. • Odum's model is designed for simple ecosystems such as grassland and would be difficult to apply to more complex systems such as those in NZ. 	
The way forward for progressing restoration management (FUT)			
FUTRESGUIDE Does restoration require some specific guidance/models for best practice? If so, what might they look like? How do we incorporate ecological theory? If not, why not? How can we learn from existing restoration efforts?	<ul style="list-style-type: none"> • There are very few places in Auckland that have the potential to be self-sustaining restoration sites. Restoration guidance needs to recognize this at the outset and factor it in to costs for ongoing management etc. • Future restoration guidance needs to recognize diversity. E.g. council plantings shouldn't prescribe the same sets of plants in the same age group to put in the ground because they risk getting all wiped out at once. • Guidance should factor in the multi-disciplinary questions that are raised during restoration e.g. what nature to restore for aesthetics versus ecological purity – there can be a happy medium between the two. • Guidance really does need to take a strong focus on reinstating ecological processes 	<ul style="list-style-type: none"> • Complete eradication of pests may not be a necessary measure to enable a system to start ticking over again. Goals need to focus on what level of control is needed to enable sustainable function of the system. • Te FORMAC system will enable restoration practitioners to monitor and enter all their information into one national database. If they can get the quality assurance on data then it could be really useful. It may not be government who regulate or own it however. • There needs to be some clear definitions around what is considered successful and what is considered a failure. • Guidance should not delude practitioners in urban restorations that they can expect to achieve something pristine. • Restoration priorities should not be set simply based on their ecological value, but also on their potential ecological value i.e. if you have a strong community group wanting to pursue a project then this should be given priority as well. • Sensible Restoration goals for sites need to take in the context of the productivity of the 	<ul style="list-style-type: none"> • Restoration guidance could focus more on what people are getting out of it and how to progress those symbiotic relationships between people and ecosystem (kind of like permaculture), rather than the steps such as weeding, planting etc. • Maori people could be more involved in future restoration planning, especially relating to building in things such as cultural harvesting. • Future restoration guidance should focus on methods to GENTLY make the conditions right for nature to do its own thing. The scraping back of systems approach that commonly takes place at present may be too harsh. • We need to adhere more to the RMA with regards to restoration – few restoration projects are about remedying the effects of past actions – most of them are dealing with the effects of current proposals. • Government needs to do a lot more to support restoration through legislation

	<p>rather than ecological structure – this means considering which exotics are ok for getting processes going (i.e. non-invasive) to use/leave in projects. This should be reflected in project goals.</p>	<p>surrounding landscape e.g. no good planting trees with the expectation that it will extend a nearby remnant in 100 years if the nearby remnant is going to be cut down/removed/die off in 50 years.</p> <ul style="list-style-type: none"> • There is enough ecological information out there on e.g. pest control to be able to make some reasonable predications on what outcomes can be achieved if you remove XX pest. This information needs to be communicated better from the ecologists – restoration practitioners. • Ecological restoration actually provides another test for this ecological theory without having to do more of the same ecological studies again and again. • Ecological concepts need to be communicated to practitioners in way that is meaningful and understandable to them. • Tools such as the Plant Finder need to be extended to include ecosystems other than just lowland forest. These tools should not only be used by practitioners but also by consent officers as well. • Ecological restoration is about urgency. Restoration goals need to keep this in perspective. • Volunteers could be used for restoration activities other than just tree planting. • If restoration goals only focus on one element e.g. birds, then the management activities that follow may mean that other parts of the ecosystem miss out. So for birds, possum control may be in place and rodent control may get missed out – but this impacts on e.g. lizards in the ecosystem. • Goals for structure are more easily understood than goals for processes/function as they seem less tangible to measure. Need to communicate goals for function in ways that practitioners will understand e.g. make streams more swimable for kids – this brings in implications of water quality etc. • Restoration guidance should make people recognize that they are central in the environment and that they are a central part of the equation in solving the problem. – so again, emphasizes the importance of seeing things 	<p>and policy.</p> <ul style="list-style-type: none"> • We need to educate the next generation a lot more about the environment – to help them develop some sense of value for it so that when they grow up they will understand that they need to take care of it. This is particularly important because we are becoming increasingly separate from our natural environment. • Guidance for restoration is really site specific, but the best general approach is to identify what's growing on your site already, what's growing in the patches around it, get those species identified. Go for the species tht are growing on edges, or the scrubby stuff. Plant those, and later on put in those bigger trees that are growing around the place. Obviously you need some knowledge to start with to be able to identify species. • It is important to choose appropriate species – even with ongoing maintenance, you can't make a planting work if ecologically, it's not supposed to be there. • A description of the restoration process needs to incorporate all the different roles that people have in restoration and how this affects the development and performance of the ecosystem. You could even go so far as to compare different planting techniques, maintenance etc and the continuum of effects that these have. In essence, all of these factors contribute to the overall success of your restoration so we need to understand them. You could also incorporate seasonal influences into this. • Restoration guidance needs to take on a landscape focus – so even if it is not about restoring an entire landscape, the catchment around the site should be a minimum consideration in all restoration projects. • Need to take into consideration ecosystem processes more when restoration is being planned – e.g. leave logs in for lizards, nutrient cycling,
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		<p>from a catchment perspective.</p> <ul style="list-style-type: none"> • Restoration would have far more groundswell if natural capital was recognized by government – understanding the \$\$ value of nature would really help build more of a case for restoration. This should include recognizing the value of urban restoration too. • A good restoration strategy should be an amalgamation of what people want and what is going to work ecologically. But you still need to have a framework whereby you drive points about what is best ecologically. This should really be the primary focus and then you can say, given that, what do the people want? • Islands provide good models on the process of managing people, not necessarily environment. • Islands like Tiri also provide the sociological component necessary for educating and engaging people to do restoration. • Care needs to be taken with the sites that are chosen as references for restoration – every restoration site is unique and different and you can't expect to achieve a replica. This needs greater emphasis. • Self sustainability is something that is probably impossible for urban restoration sites – these cost (of perpetual maintenance) need to be factored in when setting priorities for regional restoration action. This brings in the social consideration of the level of community support (labour avail.) again. • Restoration guidance may be more consistent if councils were not so compartmentalized – i.e. different groups have different ideas about what biodiversity/conservation/restoration means. • It's not lack of knowledge that's holding us back in restoration – its getting the people to do it and to do the non-sexy stuff like weeding. 	<ul style="list-style-type: none"> • sediment catching, microclimate etc. • Restoration needs to create 'wild' places as well (those that limited by OSH/social reasons). These need to be in walking distance to urban areas so that people can really learn about the natural environment & processes. •
<p>FUTRESRACT</p> <p>What is the best way to collect and share the results of restoration projects between sectors?</p> <p>If restoration is a science, should we develop some sound methods for feeding back information between</p>	<ul style="list-style-type: none"> • Restoring urban areas back into pristine conditions is a romantic idea. Restoration in future needs to work with the exotics, not so much against them – i.e. focus on functional success rather than structural purity. We need to recognize that PEOPLE are an exotic species in the context of the ecosystem we are 	<ul style="list-style-type: none"> • All land management should be recognized as restoration. We're in battle mode to halt decline and this isn't going to happen by simply conservation management. The forces influencing degradation are too strong. • Restoration helps people to develop an emotional tenure to a place – a sense of attachment and belonging. Restoration practice needs to engage people on this level for it to be successful. 	<ul style="list-style-type: none"> • Practitioners need to be recording their results and learnings as they go – although it would be preferable to do this systematically through monitoring, it is still a vast body of knowledge and future practitioners can benefit from this. • Need to enable more "Friends of" systems in projects so that people feel like they have more ownership of project. • The public is a hugely under-used

<p>practitioners and scientists and vice versa?</p>	<p>restoring.</p> <ul style="list-style-type: none"> • There should be some regulation that restoration projects must compulsorily take a look at the wider context and implications of restoration – how the landscape affects the project and how the project fits into the bigger picture. This would inevitably involve a larger number of groups in the scheme of the project e.g. councils, private landholders – those groups that exist outside of the project boundaries. • Councils could do a much better job at training/educating volunteers on aspects of restoration other than tree planting e.g. setting pitfall traps, monitoring – imparting specialist skills to volunteers and practitioners. • If scientists want the information from restoration projects then they need to go in and train volunteers how to get it – and how to get quality assurance on the data. • Scientists need to use non-technical language to communicate scientific concepts and methods to practitioners. 	<ul style="list-style-type: none"> • Restoration will always have maintenance of some kind in perpetuity. In order for this to be successful, projects need to clearly communicate what the goals are and how they have been achieving them, so that future practitioners can come in and keep the momentum going efficiently and effectively. • Need to be able to put a \$\$ value on e.g. changing someone's attitude to the environment, as much as the value of the environment needs to have \$\$ values put on it. This may help to communicate restoration outcomes and value to e.g. government or funders. • It may be easier to collect data from one or two indicators that are saleable to the public e.g. possums, rats but identify what their removal means to other parts of the ecosystem e.g. nutrient cycling. I.e. it is easier to communicate: if we remove this many possums then it will have this impact on nutrient cycling, than going in and talking about the nutrient cycling first off. This then needs to be relayed in terms of what it means in costs. • Indicators therefore should be easy to measure and imply implications for the progress of a number of other processes and species in the ecosystem. • Being able to monitor restoration might be connected to giving people ownership of restoration. E.g. you might encourage someone who has planted trees to come back next year and "see how they're going" but the reality is you are getting them to do monitoring work. But putting it in these terms gives them a sense of ownership and responsibility and connection to the plantings. May help to sustain restoration efforts in future. • Need to give people a sense that through restoration they are addressing the welfare of people as much as they are addressing the welfare of the land. • Need to merge ecology with what people want to have successful restoration e.g. people like seeing flowers around the city so restore native flowering plants around cit such as pohutukawa. • All restoration is a giant experiment which is 	<p>resource for restoration.</p> <ul style="list-style-type: none"> • Restoration concepts need to be built in more to everyday urban planning e.g. permeable paving, streams in cities. Crack open the city and let ecology in. If we don't take this into consideration nature will eventually fight back e.g. floods in Tauranga and Coromandell. • Restoration is dependent on understanding partnerships – those that are between community, businesses and local and central government and understanding the partnership between people and nature. • To get people motivated and interested in restoration they need to experience the magic of discovering nature for themselves at a very young age. More could be done to engage schools in restoration – it should be compulsory. • Landscape architects need to bring in a bit more ecological purity to their work. • Restoration may be more successful if some of the political issues are resolved e.g. high profile landscapes lost and traded for revegetation by developers. • A greater amalgamation between what people want and what is ecologically possible should be a united goal between all sectors involved in landscape modification, whether its restoration, ecological research, landscape architecture, property development, urban design and planning. This may forge closer relationships between these sectors and strengthen and support restoration more. • For restoration to receive more widespread support, it needs to be seen in the context of what people can get out of it – how can people benefit from the fruits of restoration, economic opportunities, art in the park, swimming? • There would be more opportunity to share the results of restoration if there was some requirement to collect or document the information in the first place!
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		<p>why monitoring is such a necessity.</p> <ul style="list-style-type: none"> • People are a very powerful factor in influencing what happens in restoration e.g. manuka and kanuka are not planted in some (council) restorations so much now because people (volunteers) are sick of planting the same and want more diversity in their experience. • Restoration needs to be considered in the landscape context – e.g. with patches – some may blink in and out of the system over time. Individually this may be considered a problem but from a landscape perspective, where species are traveling from patch to patch, it may not necessarily matter if one blinks out. 	<ul style="list-style-type: none"> • Need to instill a sense of responsibility to the public on restoration – the success of restoration efforts in perpetuity is dependent on this. The best way to do this is to get people enthusiastic about it – educate them from a young age.
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